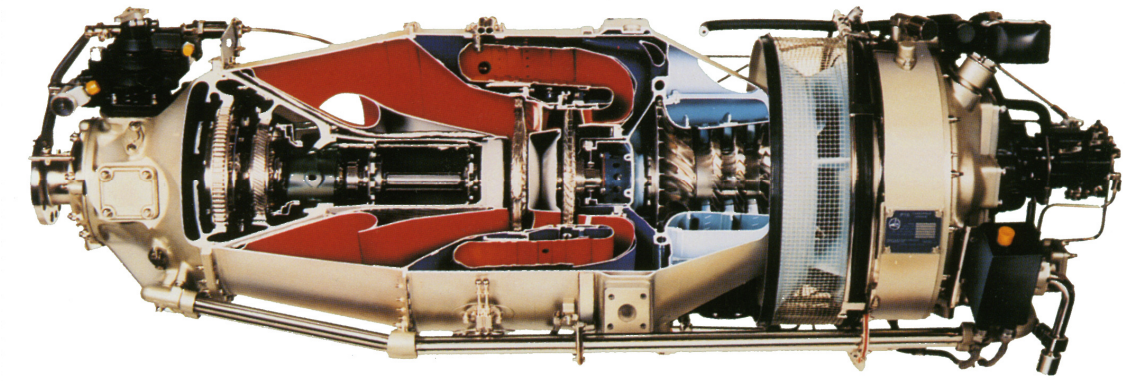
PT6

DESCRIPTIVE COURSE
AND
GUIDE TO TROUBLESHOOTING



Training for PT6 engines technicians focused on resolving problems in the field.

- ***Description of engine modules*: Compressor, Hot Section, Power Section, Accessory Gearbox and Reduction Gearbox**
- ***Systems:* Fuel, Air, Oil and Electrical**
- ***Integration* of all Systems**

Training offered by:

UNITED TURBINE

We keep your PT6 flying!

ENGINE DIRECTIONAL REFERENCES

The terms right and left, clockwise and counterclockwise, upper and lower, and similar directional references will apply to the engine as viewed from the rear with the engine in a horizontal position and the accessory case facing the viewer. When components or struts are numbered in a circumferential direction, the No.1 position is at 12 o'clock, or the first immediately clockwise position increase arithmetically in a clockwise direction when viewed from the rear.

ENGINE DESCRIPTION

The PT6 power plant is a lightweight, free-turbine engine. Pressure ratio varies form 6.3:1 for early model engines to 10.0:1 for the second generation. Power ranges from 475 to 1700 SHP are achieved. The engine utilizes two independent turbine sections; one (compressor turbine) driving the compressor in the gas generator section, and the second (power turbine – two-stage in larger model engines) driving the output shaft through a reduction gearbox. The engine is self sufficient since its gas generator driven oil system provides lubrication for all areas of the engine including pressure for the torquemeter and power for propeller pitch control.

Inlet air enters the rear of the engine through annular plenum chamber formed by the compressor inlet case where it is directed forward to the compressor. The compressor consists of three axial stages (four on –65 an larger engines) combined with a single centrifugal stage assembled as an integral unit. The rotating
compressor blades and impeller add energy to the air passing through them by increasing its velocity.

A row of stator vanes located between each stage of compressor rotor blades diffuses the air, converting velocity into pressure, and directs it at the proper angle to the next stage of compression. From the tips of the centrifugal impeller, the air passes through diffuser tubes (diffuser vanes in older model engines), which turn the air through 90 degrees in direction and also convert velocity to pressure. The diffuser air then passes through straightening vanes to the annulus surrounding the combustion chamber liner.

The combustion chamber liner consists of an annular weldment having perforations of various sizes that allow entry of compressor delivery air. The flow of air changes direction 180 degrees as it enters and mixes with fuel. The location of the liner outside the turbines eliminates the need for a long shaft between the compressor and the compressor turbine, thus reducing the overall length and weight of the engine. Fuel is supplied by a dual manifold (single on early engine models) consisting of primary and secondary transfer tubes and adapters. The fuel / air mixture is ignited or glow plugs which protrude into the liner.

The resultant hot gases expand from the liner, reverse direction in the exit

duct zone and pass through the compressor turbine inlet guide vanes to the single – stage compressor turbine. The guide vanes ensure that the expanding gases impinge on the turbine blades at the correct angle, with minimum loss of energy. The still expanding gases continue forward to drive the power turbine section, which in turn drives the prop shaft through a two–stage planetary reduction gearbox. The reduction gearbox embodies an intergral torquemeter device which is instrumented to provide an accurate indication of engine power.

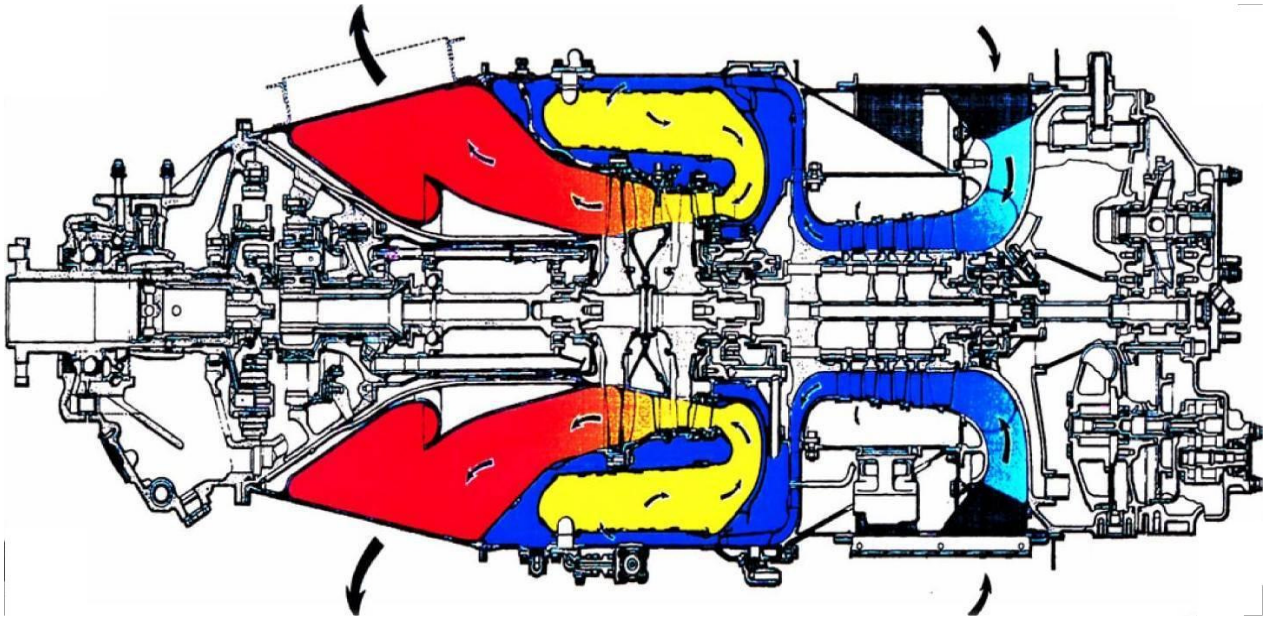
The compressor and power turbines are located in the approximate center of the engine with their respective shafts extending in opposite directions. Their feature provides for simplified installation and inspection procedures. The exhaust gases from the power turbine are directed through an annular plenum to atmosphere via twin opposed ports provided in the exhaust duct.

Interturbine temperature (T5) (turbine inlet temperature (T4) on PT6A-6 series) is monitored by an integral probe, bus-bar, and harness assembly installed between the compressor and power turbines with the probes projecting into the gas path. A terminal block, mounted on the gas generator case (exhaust case in late model engines), provides a connection point to cockpit instrumentation.

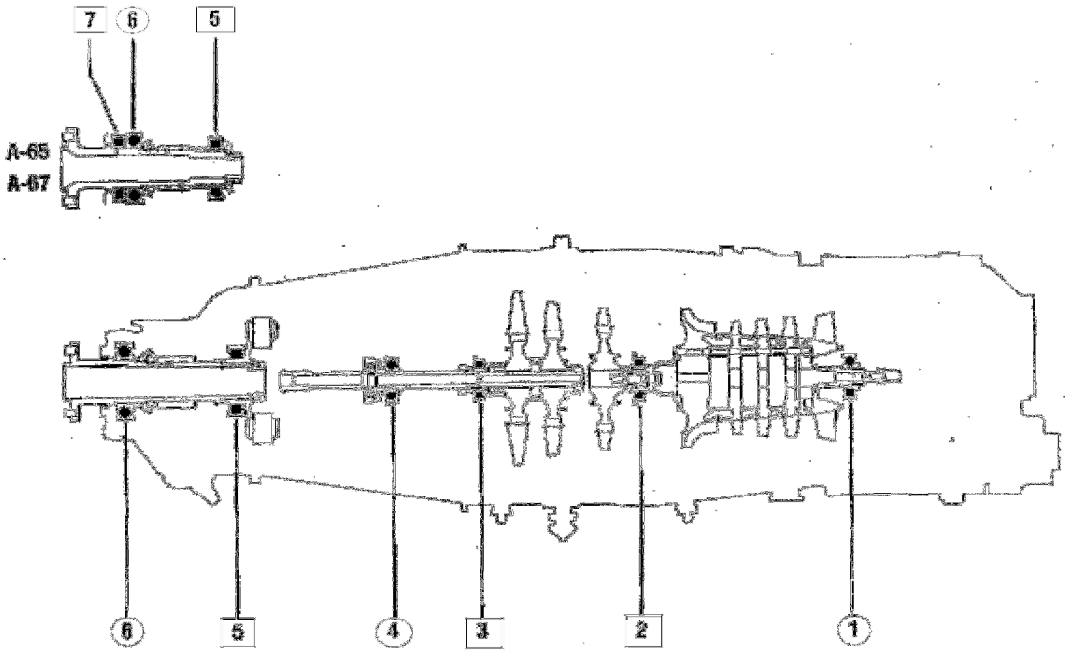
All engine driven accessories (with the exception of the propeller governor, power turbine overspeed governor and power turbine tachometer-generator) are mounted on the accessory gearbox at the rear of the engine. These components are driven off the compressor by means of a coupling shaft which extends the drive through a conical tube in the center section of the oil tank. The rear location of accessories provides for a clean engine and simplifies any subsequent maintenance procedures.

The engine oil supply is contained in an integral oil tank which forms the rear section of the compressor inlet case. The tank has a total capacity of 2.3 US gallons and is provided with a dipstick and drain plug.

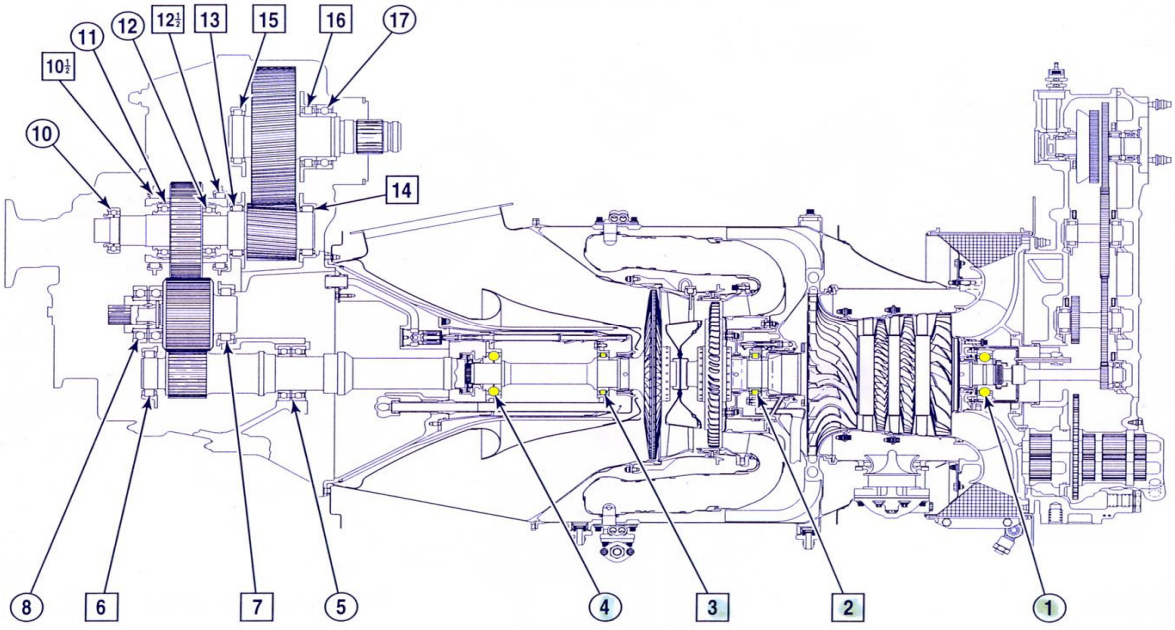
Fuel supplied to the engine from an external source is further pressurized by an engine–driven fuel pump and its rate of flow to the fuel manifold is controlled by the fuel control unit (FCU) which is also engine driven.



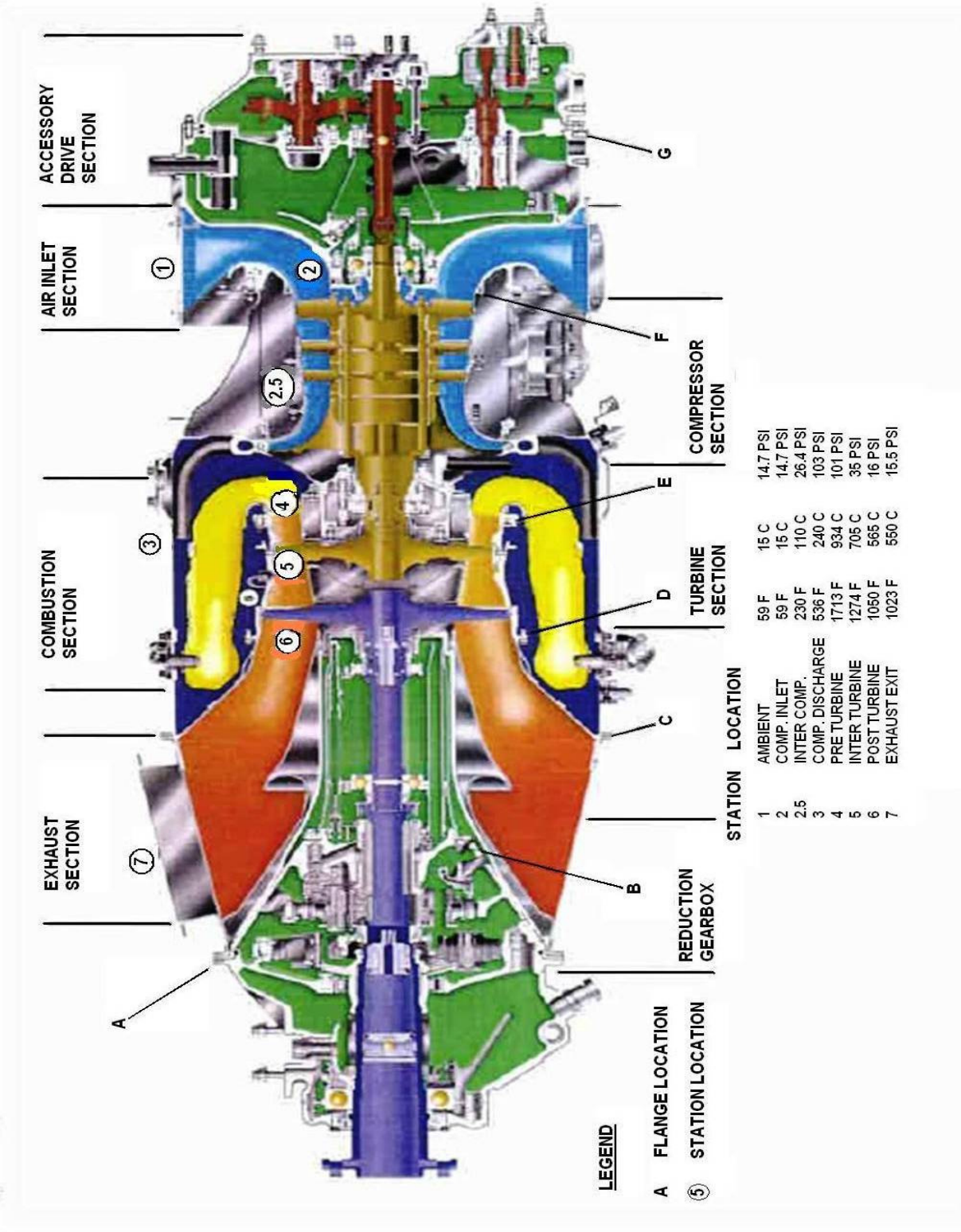
AIRFLOW



BEARINGS



BEARINGS


ACCESSORY DRIVE SECTION
AIR INLET SECTION
COMBUSTION SECTION
EXHAUST SECTION
COMPRESSOR SECTION
TURBINE SECTION
REDUCTION GEARBOX
LEGEND
A FLANGE LOCATION
⑤ STATION LOCATION
STATION LOCATION
1 AMBIENT 59 F 15 C 14.7 PSI
2 COMP. INLET 59 F 15 C 14.7 PSI
2.5 INTER COMP. 230 F 110 C 26.4 PSI
3 COMP. DISCHARGE 536 F 240 C 103 PSI
4 PRE TURBINE 1713 F 934 C 101 PSI
5 INTER TURBINE 1274 F 705 C 35 PSI
6 POST TURBINE 1050 F 565 C 16 PSI
7 EXHAUST EXIT 1023 F 550 C 15.5 PSI

PT6 ENGINE MODEL SUMMARY

1. **PT6A-6**
   First PT6 engine certified, non-reversing. 550 Shaft Horsepower (SHP) for Takeoff (TO) at 2200 prop rpm. Turbine Inlet Temperature (TIT) indication (T4).

2. **PT6A-6A**
   Same as PT6A-6 with A-6 reversing system.

3. **PT6A-6B**
   Same as PT6A-6 with A-20 style reversing system.

4. **PT6A-6/C-20**
   Limited number of PT6A-6 converted at overhaul to A-20. Updated with interstage turbine temperature (ITT) system (T5).

5. **PT6A-20**
   550 SHP TO at 2200 propeller rpm Introduces T5 temperature indication system, ITT.

6. **PT6A-20A**
   Same as A-20 except with A-27 exhaust duct and A-27 style propeller governor.

7. **PT6A-20B**
   Same as PT6A-20A except with A-20 reversing system. Used by Pilatus.

8. **PT6A-27**
   Bored–out A-20 with diffuser pipes, fine mesh reduction gears, one piece CT vane ring, etc. 680 SHP for TO at 2200 propeller rpm.

9. **PT6A-28**
   Mechanically identical to A-27 but with high cruise rating for corporate type aircraft such as the King air E-90, -100, A100 and Piper Cheyenne. 680 SHP for TO at 2200 propeller rpm.

10. **PT6A-29**
    Very similar to A-27 with 750 SHP at TO. Used only by US army.

11. **PT6A-21**
    Mechanically identical to a -27 but using reduction gears like -20 and has only one line of fuel nozzles. 550 SHP at 2200 propeller rpm.

12. **PT6A-25**
    Mechanically identical to A-21 except for modifications required for inverted flight. Used by US Navy in T-34 trainer. 550 SHP for TO at 2200 propeller rpm.

13. **PT6A-25A**
    Mechanically identical to A-25 except for modifications to front RGB casing, different torque controller settings and no reversing. Used in Pilatus PC-7 trainer.

14. **PT6A-25C**
    Introduces a hot section similar to –34. It is use on trainer Tucano. Modified for inverted flight

15. PT6A-11
First model of the A-10 series to enter production. Basically a PT6A-27 fitted with a PT6A-20 reduction gearbox. Flat rated to 500 SHP for takeoff at 2200 propeller rpm

16. PT6A-11AG
Identical to PT6A-11 with the addition of corrosion protected hardware and special design features for agricultural aviation. Certified for unlimited operation on diesel fuel.

17. PT6A-110
Identical to PT6A-10 (uncertified) except for the incorporation of low speed reduction gearbox. Flat rated to 475 SHP for TO at 1900 prop rpm.

18. PT6A-112
Similar to A-11 but with 1900 RPM reduction gearbox. 500 SHP for TO.

19. PT6A-15AG
Mechanically Identical to PT6A-27 but with the incorporation of corrosion protected hardware and special design features for agricultural aviation. Certified for unlimited operation on diesel fuel. Flat rated to 680 SHP for TO at 2200 propeller rpm.

20. PT6A-34
Identical to PT6A-27 except for the air-cooled hot section which is basically T-3 style. 750 SHP for TO at 2200 propeller rpm.

21. PT6A-34AG
Identical to A-34 except for single taper compressor turbine blades (A-42), P3 filter and 50-hole compressor wash ring. Used in Ayres Rockwell Thrust & Frakes Grumman AG-Cat conversions certified for unlimited operations on diesel fuel.

22. PT6A-34B
Identical to A-34 except for aluminum casings in place of magnesium. Used in Beech t-44A for US Navy.

23. PT6A-36
Identical to A-34 except is flat rated to 97 F (36 C) and has single line fuel nozzles. Used in Saga conversion of Beech C-90.

24. PT6A-114
Similar to –34 but with 600 SHP at 1900 propeller rpm and only one exhaust pipe at 5 o'clock. Used in single engine Caravan.

25. PT6A-114A
Identical to –114 but living more power 675 SHP at 1900 propeller rpm.

26. PT6A-135
Similar to A-34 with 1900 RPM reduction gearbox. 750 SHP for TO but hot section similar to -41.

27. PT6A-135A
Similar to A-34 with 1900 RPM reduction gearbox. 750 SHP for TO but hot section similar to -41.

28. PT6A-41
New technology turboprop featuring a two-stage power turbine and new increased mass flow compressor. Heavily flat rated to 850 SHP for TO at 2000 propeller rpm.

29. PT6A-41AG
Identical to PT6-41 but with the addition of corrosion protected hardware and special design features for agricultural aviation. Certified for unlimited operation on diesel fuel.

30. PT6A-38
Mechanically identical to A-41 except with un-cooled C/T vane. 750 SHP for TO at 2000 prop rpm.

31. PT6A-42
Identical to PT6A-41 but with compressor improvements to give some 10% increase in cruise performance.

32. PT6A-42 A
Identical to PT6A-41, 850 SHP at 2000 propeller rpm.

33. PT6A-45A
Very similar to A-41 but using a higher power turbine speed reduction. 1173 SHP for TO at 1700 propeller RPM. Used in Shorts SD3-30 Mohawk 298 (Nord 262) aircraft.

34. PT6A-45B
Identical to PT6A-45A but with increased water injection to give improved thermodynamic performance.

35. PT6A-45R
Identical to PT6A-45A but with increased water injection to give improved thermodynamic performance.

36. PT6A-50
Similar to PT6A-41 but with new reduction gearbox for lower propeller speed. 1120 SHP for TO at 1210 prop rpm. Used in DHC-7 Short Takeoff and Landing (STOL) airliner.

37. PT6A-60A
Same compressor as the -41 but the hot section and power section are like -65 series. 1173/1400 SHP at 1700 propeller rpm. Used on King Air 300 and 350.

38. PT6A-60AG
Identical to PT6-60A but with the addition of corrosion protected hardware and special design features for agricultural aviation. Certified for unlimited operation on diesel fuel.

39. PT6A-61, 61A
Same as -60A but rated at 850 SHP or 950 SHP depending on BS of the engine.

40. PT6A-62
Similat to -61 with 950 SHP at 2000 propeller rpm. Used on Pilatus PC-9.

41. PT6A-64
Same as -66 but with less power 700 SHP at 2000 propeller rpm.

42. PT6A-65B
Introduction of new technology. The compressor has four axial stages and one centrifugal. The bleed valve reintroduces the air into the compressor inlet. The combustion chamber is made up to two parts, inner and outer. The FCU is manufactured by Woodward. 1173 SHP at 1700 propeller rpm. Used on Beech 1900.

43. PT6A-65R
Similar to -65B but with reserve power to reach 1327 SHP.

44. PT6A-65AR
Similar to –65B but with the power increased to 1424 SHP. Used on Short 360.

45. PT6A-65AG
Identical to PT6-65B but with the addition of corrosion protected hardware and special design features for agricultural aviation. Certified for unlimited operation on diesel fuel.

46. PT6A-66, A, B, D
Similar to -65B but rated to 850 / 950 SHP. And a gearbox like-41 at 2000 propeller rpm. It can be maintained as three modules.

47. PT6A-67
Similar to -65 with 1400 test /1300 SHP at 1700 propeller rpm.

48. PT6A-67A
Similar to -65 with 1400 test /1300 SHP at 1700 propeller rpm.

49. PT6A-67B
Similar to -65 with 1450 test /1300 SHP at 1700 propeller rpm.

50. PT6A-67AF
Has 1424 test /1300 SHP at 1700 propeller rpm.

51. PT6A-67AG
Similar to -67AF 1424 test/1300 SHP at 1700 propeller rpm. but with the addition of corrosion protected hardware and special design features for agricultural aviation. Certified for unlimited operation on diesel fuel

52. PT6A-67R
Has 1424 test/1300 SHP at 1700 propeller rp.

53. PT6A-67T
Has 1424 test/1300 SHP at 1700 propeller rp.

54. PT6A-67D
Has 1450 test/1300 SHP at 1700 propeller rpm.

55. PT6A-67P
Has 1450 test/1300 SHP at 1700 propeller rpm.

56. PT6A-67F
New design with 1700 SHP at 1700 propeller rpm. Used on Air Tractor 802 “Fire Boss” fire fighting.

57. PT6A-68
1250 SHP at 2000 propeller rpm. Used on Texan II (Pilatus) trainer, modified for inverted flight.

58. **PT6A-68B**
Has 1600 SHP at 2000 propeller rpm. Used on Pilatus PC-21, modified for inverted flight.

59. **PT6A-68C**
Has 1600 SHP at 2000 propeller rpm. Used on Super Tucano trainer, modified for inverted flight.
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60. **PT6B-9** (Turboshaft)
Similar to PT6A-6 but with single reduction gear stage. Very few engines. In use with Lockheed helicopter.

61. **PT6B-36A, -36B** (Turboshaft)
981 SHP a 6409 rpm eje, con 2 ½ y 30 minutos OEI a 1033 SHP.

62. **PT6B-37A** (Turboshaft)
Similar to A-34 but using single stage reduction gear for helicopter application. 750 SHP for TO, at 6188 output shaft rpm.

63. **PT6B-67A** (Turboshaft)
Similar to A-67 but using single stage reduction gear for helicopter application. 1000 SHP for TO, at 6188 output shaft rpm.

64. **PT6C- 67C** (Turboshaft)
Similar to -67. Used on August Westland AW139 with 1100 SHP at 21000 shaft rpm.

65. **PT6C-67D** (Turboshaft)
Develops 1183 SHP at 21200 shaft rpm.

66. **PT6C- 67E** (Turboshaft)
Similar to -67C and -67D …

67. **PT6D-114A** (Turboshaft)
Based on the PT6A-114A but without the second stage reduction

68. **PT6T-3** (Turboshaft)
Twin Pac using two 900 SHP gas generators and a combining gearbox. 1800 SHP at 6600 output shaft rpm. Used in Bell 212, AB-212 and Sikorsky S58T.

69. **PT6T-3A** (Turboshaft)
Same as a PT6T-3 but with with aluminum (instead of magnesium) gearbox casting. No longer used.

70. **PT6T-3B** (Turboshaft)
Basically a PT6T-3 but fitted with the improved hot end components of PT6T-6. Emergency single power section contingency rating of 970 SHP for 30 minutes and 1025 SHP for 2 ½ minutes. Used on Bell 212/412.

71. **PT6T-3BE** **(**Turboshaft)
Same as the PT6T-3B with the removal of the torque sharing function in the torque control. USED on Bell 212/412.

72. **PT6T-3BF**
Similar to the PT6T-3B, except 30-minute OEI rating is equivalent to the 2½ minute OEI rating, 1025 SHP. Used on Bell 212/412.

73. **PT6T-3BG** (Turboshaft)
Similar to the PT6T-3BF, but without the torque sharing function in the torque control. Bell 212/412.

74. PT6T-6 (Turboshaft)
Same as the PT6T-3, except for the 2½ min rating and higher ratings and improved engine parts. 1875 SHP for TO. Utilized in S58T, AB-212 & version of AH-1J.

75. PT6T-6B (Turboshaft)
Same as the PT6T-6 with the removal of the torque sharing function in the torque control.

76. PT6T-3D (Turboshaft)
Same as the PT6T-3B, except for improved hot section hardware to allow for increased ratings with an engine inoperative (OEI), 1024 SHP continuous and 1133 SHP for 2 ½ minutes..

77. PT6T-3DE (Turboshaft)
Same as the PT6T-3D, except the continuous OEI rating is 1079 SHP and 1133 SHP for 2 ½ minutes.

78. PT6T-3DF (Turboshaft)
Same as the PT6T-3DE, except for improved hot section hardware to allow for increased ratings.

79. PT6T-9 (Turboshaft)
Similar to the PT6T-3DF, except for an improved hot section and it is equipped with an engine electronic control system.

80. T74-CP-700
Military version of the PT6A-20

81. T74-CP-701
Military version of PT6A-27.

82. T74-CP-702
Military version of the PT6A-29

83. T400-CP-400 (Turboshaft)
Military version of the T-3, utilized in UH-1N and AH-1J.

84. T400-WV-401 (Turboshaft)
Similar to T400-CP-400 but with T-3 features satisfying civil certification requirement.

85. T400-WV-402 (Turboshaft)
Uprated version of the T400-CP-400 similar to PT6T-6, utilized in AH-1J.

ENGINE CONSTRUCTION

GENERAL

This manual is based on a generic PT6 engine. Major differences between models have been noted, but for work done on an engine, Pratt & Whitney manuals must be used.

COMPRESSOR INLET CASE

The compressor inlet case is a circular casting, the front of which forms plenum chamber for the passage of compressor inlet air. A wire mesh screen, which is secured around the air intake case prevents ingestion of foreign objects by the compressor. The rear of the inlet case forms an intergral oil tank and incorporates oil passages for pressure and scavenge oil. A drain plug orifice is situated in the base of the tank case and accommodates a drain plug, held in position by a pin which fits plug, held in position by a pin which fits through integral brackets at each side of the orifice. An oil pressure pump, which embodies a pressure relief valve, is located in the lower part of the tank and is secured with bolts to the accessory gearbox diaphragm. A port on the right hand side of the casing provides a mounting position for the engine main oil filter housing which incorporated s filter check valve and bypass valve assembly.

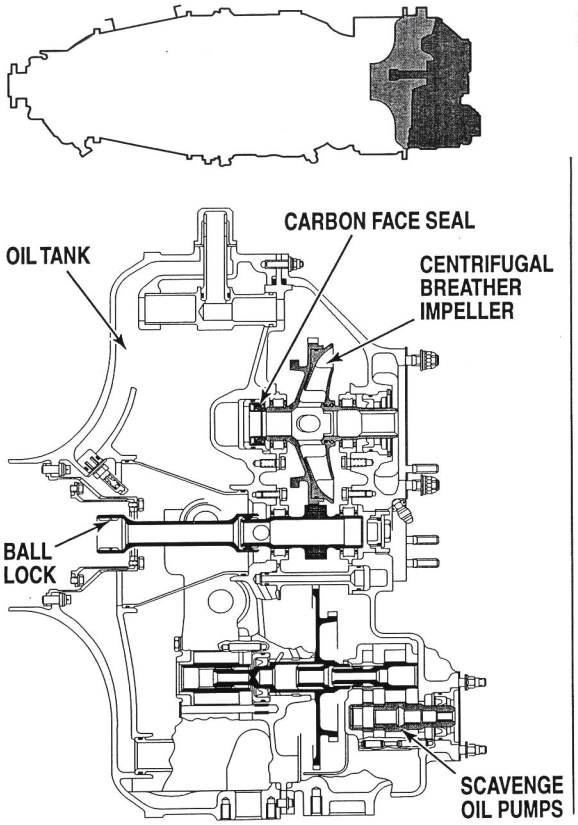
The No.1 bearing, bearing housing and labyrinth seal are housed within the inlet case centerbore. The bearing housing with support and adapter set is bolted to the centerbore flange, The No.1 bearing outer race being retained in the support by an internal keywasher and spanner nut. Lubrication of the bearing is provided by an oil nozzle which is fitted at the end of one of the pressure oil passages in the casing.

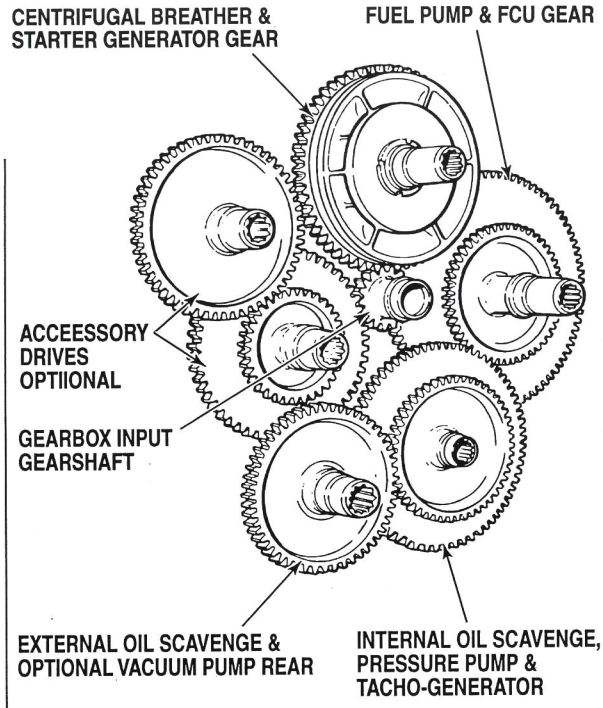
A tapered tube, complete with preformed packing at each end, is located between the centerbores of the compressor inlet casing and the accessory gearbox diaphragm and provides a passage through which a coupling shaft drives the rear accessories.

COMPRESSOR ROTOR AND STATOR ASSEMBLY

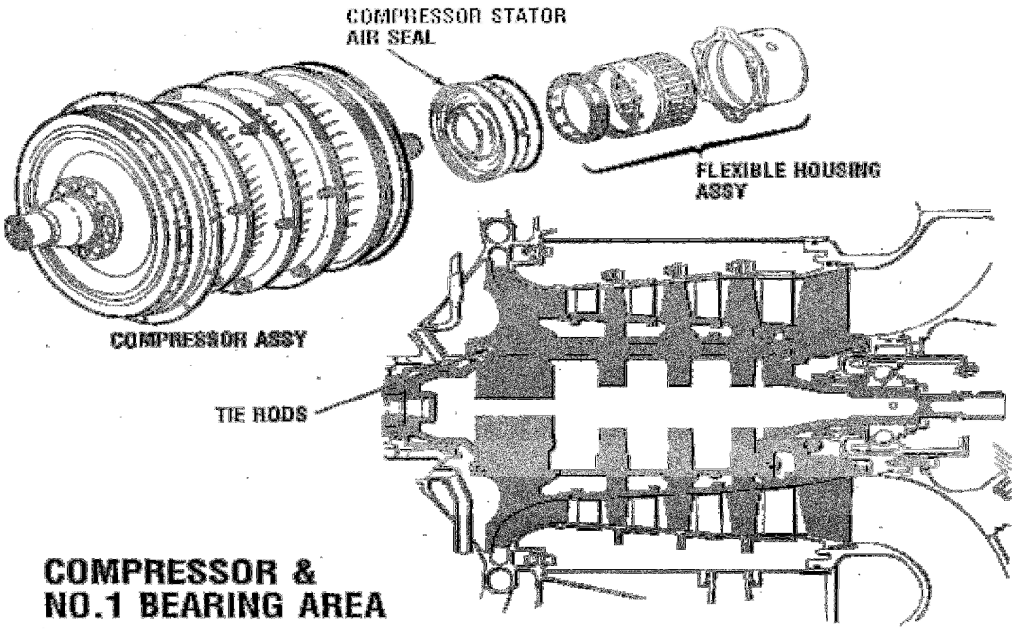
The compressor rotor and stator assembly consists of a three-stage axial rotor, three interstage spacers, three stators and single stage centrifugal impeller and housing. The first stage rotor blades (wide chord) are of titanium to improve impact resistance, while the second and third stage rotors are of stainless steel. The rotor blades are dovetailed into their respective disks, the clearance between blades and disk produces the metallic clicking heard during compressor rundown. Axial movement of the rotors is limited by the interstage spacers located between the disks. The airfoil cross section of the first stage blades differs from those of the second and third stages which are identical. The length of the blades differs in each stage, decreasing from first to third stage.

The first and second stage stator assemblies each contain 44 vanes and the third stage 40 vanes. Each set of stator vanes is held in position by a




CENTRIFUGAL BREATHER & STARTER GENERATOR GEAR
FUEL PUMP & FCU GEAR
ACCEESSORY DRIVES OPTIIONAL
GEARBOX INPUT GEARSHAFT
EXTERNAL OIL SCAVENGE & OPTIONAL VACUUM PUMP REAR
INTERNAL OIL SCAVENGE, PRESSURE PUMP & TACHO-GENERATOR

ACCESSORY GEARBOX



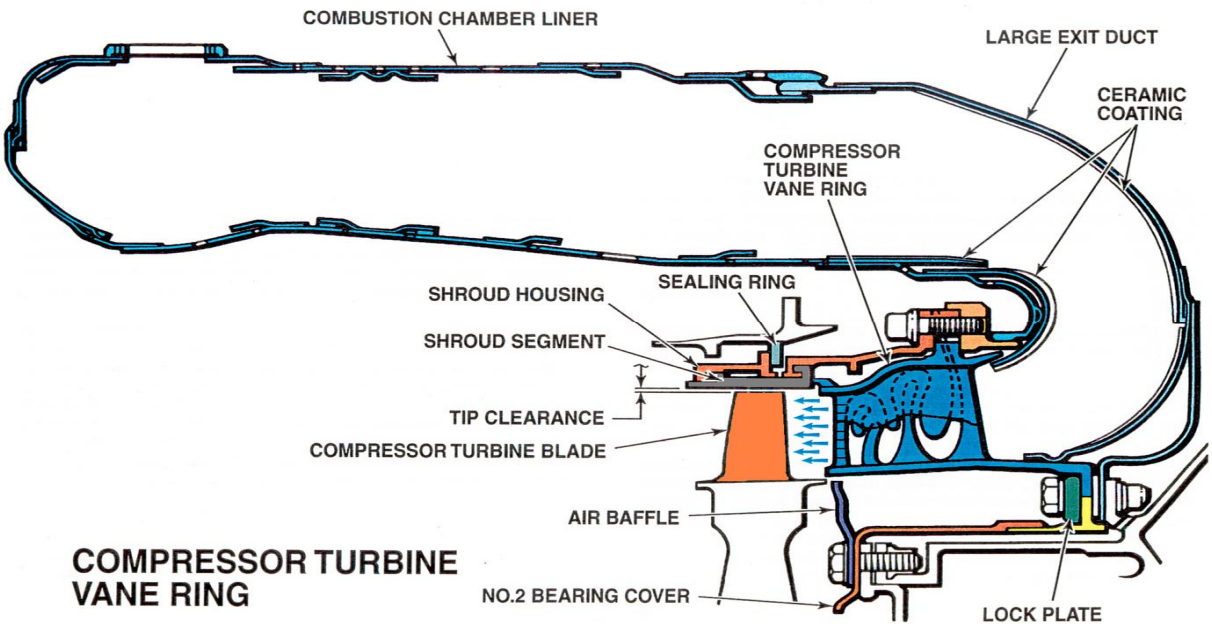
COMPRESSOR & NO.1 BEARING AREA

circular ring through which the vane outer ends protrude. Shrouds for the first, second and third stage compressor blades are provided by the respective stage vane rings. The second stage vane ring is supported inside the first and third stage stator housings which are bolted together. The third stage stator assembly is bolted to the impeller housing and embodies a locating pin which fits into a slot in the second stage to prevent rotation of the assembly. The compressor front stubshaft, centrifugal impeller and the impeller housing are positioned rearward in that order, followed alternately by an interstage spacer, a stator assembly and a rotor assembly. The rotating assembly is stacked and secured together by six tie-rods. A wedge-shaped retaining ring secures the impeller housing in the gas generator case. The roller type #2 bearing and air seals are accommodated on the compressor stubshaft. This bearing supports the stubshaft and the compressor rotor assembly in the gas generator case. The compressor rear hub is an integral part of the first stage compressor rotor disk and accommodates a labyrinth air seal rotor, a spacer and the ball type No.1 bearing which supports the rear hub and compressor rotor assembly in the compressor inlet case. A short, hollow steel coupling, externally splined at its protruding end is secured within the compressor rear hub by a transverse pin which passes through the hub and coupling. The complete compressor rotor and stator assembly fits into the center rear section of the gas generator case and is secured by the impeller housing at the front and the compressor inlet case at the rear. A short, hollow steel coupling shaft, internally splined, locates on the splined rear hub coupling to extend the compressor drive to the accessory gearbox input gearshaft. The coupling embodies a ball lock at the front end to prevent end thrust on the input gearshaft roller bearings.

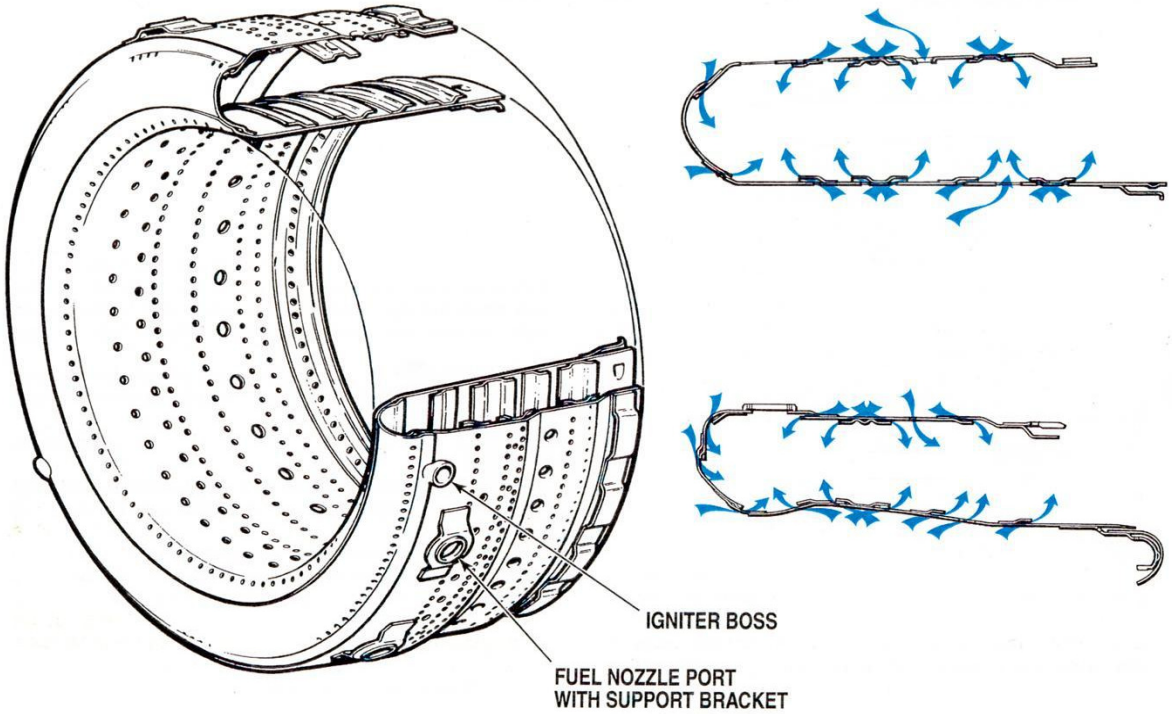
GAS GENERATOR CASE

The gas generator case is in two sections, but this single structure houses both the compressor and the combustion sections. It also provides a mounting from No.2 bearing. On –6 and -20 models it contains 14 radial vanes to provide a pressure increase and velocity decrease to the air. 70 straightening vanes with a slotted diffuser prepare the air for delivery to the combustion chamber. Four hollow vanes at the bottom provide a residual fuel drain at engine shutdown.

The gas generator case on the A-27 and later engines differ in that it contains 21 diffuser pipes brazed inside the center section of the gas generator case to provide a pressure increase to the compressed air as it leaves the centrifugal impeller. The compressed air is then directed through straightening vanes, located at the outlet of the diffuser pipes, and out to the combustion chamber liner. The gas generator case is secured to the front flange of the compressor inlet case. The rear section provides a housing for the compressor assembly and provides an outlet port for the compressor bleed valve. Cabin bleed air is ducted fr4om this area to a pad at the 1 o'clock



COMPRESSOR TURBINE VANE RING



COMBUSTION CHAMBER LINER

Two air seals, is located in the centerbore of the case. The front air seal which is the compressor turbine stator seal is bolted over a gasket to the centerbore of the case the rear air seal which is compressor front stator seal is secured inside the casing centerbore by a retaining ring. The front section of the gas generator case and the rear section o the exhaust duct form the combustion chamber. The gas generator case provides mounting bosses for the 14 fuel nozzles assemblies and the dual manifold. Mounting bosses are also provides at the 6 o'clock position for front and rear drain valves. These allow residual fuel to drain overboard during engine shutdown. Ignition glow plug or spark igniter bosses are provides at the 4 o'clock and 9 o'clock position. The plugs or igniters protrude into the combustion chamber liner to ignite the fuel air mixture. The engine is mounted on there flexible type mounts which are secured to three flexible type mounts which are secured to three equi-spaced mounting pads located on the outer circumference of the gas generator case.

COMBUSTION CHAMBER LINER AND EXIT DUCTS

The combustion chamber liner is of the reverse flow type and consists primarily of an annular heat-resistant steel liner open at one end. A series of straight, plunged and shielded perforations, allow air to enter the liner in a manner designed to provide the best fuel air ratios for starting and sustained combustion. Direction of air flow is controlled by cooling rings specially located opposite certain series of perforations. The perforations ensure and even temperature distribution at the compressor turbine inlet. The domed front end of the combustion chamber liner is supported inside the gas generator case by 7 of the 14 fuel nozzles sheaths. The rear of the liner is supported by sliding joints which fit into the small (inner) and large (outer) exit duct assemblies.

The small (inner) and large (outer) exit duct assemblies form an envelope which effectively changes the direction of gas flow by providing an outlet to the compressor turbine guide vanes.

The large exit duct contains a heat shield that forms a passage through which cooling compressor discharge air is routed. The outer flange of the large duct engages with the outer flange of the combustion chamber liner to provide an outer support for the assembly, while the center section of the assembly is bolted to a flange at the gas generator case centerbore. The small exit duct assembly is bolted to the compressor turbine guide vane support.

COMPRESSOR TURBINE VANE RING

The –6 and –20 models have individual compressor turbine vanes. The cast compressor turbine vane ring on –27 and later models have integral vanes and are located between the combustion chamber exit ducts and the compressor turbine.

The vanes direct the expanding gases to the compressor turbine blades at the optimum angle to drive the compressor.

An outer peripheral platform formed on the vane ring engages into both the shroud housing and the inner exit duct, the flanges of which are bolted together. The shroud housing extends forward to form a runner for an interstage sealing ring(s); the ring(s) provides a mechanical point of separation and an air seal for the engine. Compressor turbine shroud segments positioned in the shroud housing, act as a tip seal and allow running clearance for the compressor turbine blades. And inner shroud on the vane ring extends rearwards and has a flange by which it is secured by a pressure plate to the centerbore of the gas generator case.

COMPRESSOR TURBINE ROTOR ASSEMBLY

The compressor turbine rotor, which consists of a turbine disc, blades and classified weights, drives the compressor in a counterclockwise direction.

The turbine assembly is splined to the compressor front stubshaft and secured by a threaded turbine bolt and keywasher. A master spline is provided to ensure the disc assembly is always installed to a predetermined position to retain original balance. The 58 blades in the compressor turbine disc are held in fir-tree serrations machined in the outer circumference of the disc and are secured in position by tubular rivets.
The steel alloy blades incorporate squealer tips which ensure a minimum amount of rub should the rotating blades make contact with the shroud segments. A spot face is machined on most blades to permit checking blade stretch. The required number of classified weights are determined during balancing procedures and riveted to the relevant flanges machined on the turbine disc. A small annulus machined on the rear face of the disc, provides a sealing surface to control the flow of turbine disc cooling air.

POWER TURBINE VANE RING

Some older model engines have individual power turbine vanes. On later model engines the cast power turbine vane ring(s) have integral vanes which direct the flow of gases at the optimum angle to drive the power turbine rotor. The stator housing and containment ring with the enclosed vane assembly support the interstage sealing ring and are bolted to the exhaust duct at flange D. The interstage sealing ring is self-centering and held in position by the five mounted lugs of the interturbine busbar harness which are bolted to the rear face of the stator housing.

INTERSTAGE BAFFLE

The compressor turbine is separated form the power turbine by means of an interstage baffle, which is secured to and supported by the power turbine vane ring. The interstage baffle prevents dissipation of turbine gases and consequent transmission of heat to both turbine disc faces. The center section of the baffle includes small circular lipped flanges on the front and rear faces. These flanges fit over mating rotor seals machined on the respective turbine disc faces to provide control of cooling air flow through an orifice in the center of the baffle.

POWER TURBINE ROTOR ASSEMBLY

The power turbine rotor assembly comprised of a turbine disc (later model engines incorporate a two-stage power turbine shaft in a clock-wise direction.

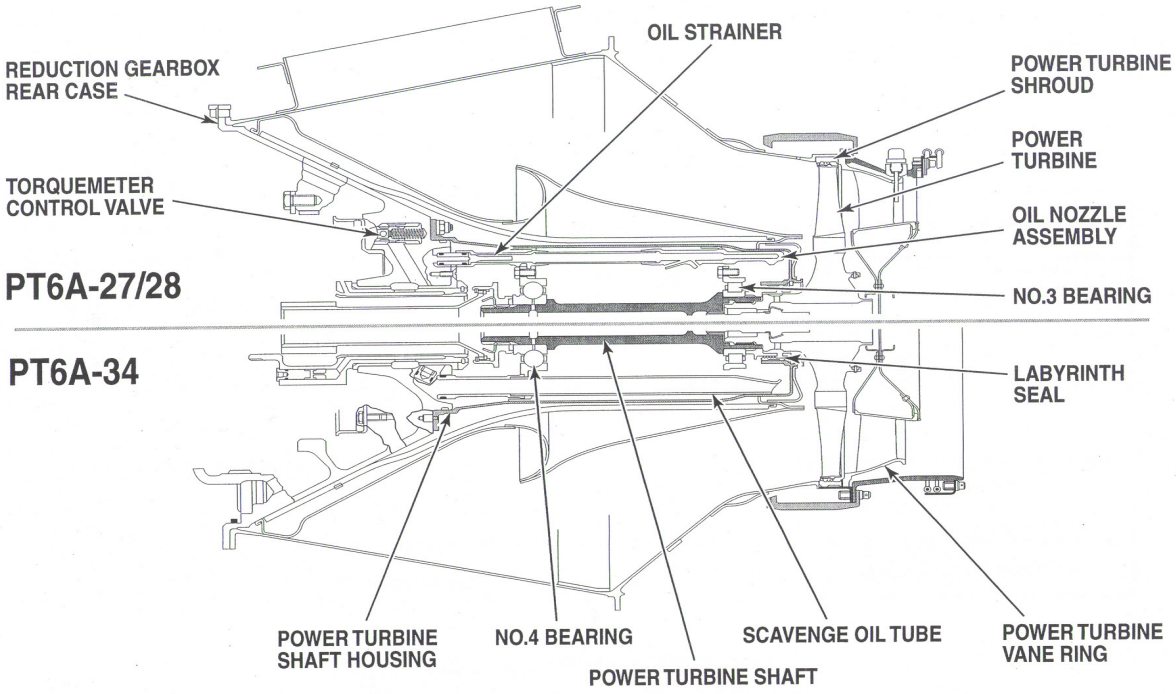
The disc is held to close tolerances and embodies a reference circumferential groove to permit disc growth measurements to be taken when required. The turbine disc is splined to the power turbine shaft and secured by a single, threaded bolt and keywasher. A master splined ensures that the turbine disc assembly is installed in a predetermined position to retain the original balance. The required number of classified weights, determined during balancing procedures, is riveted to a special flange located on the rear o f the turbine disc. The power turbine blades differ from those of the compressor turbine in that they are formed with potched and shrouded tips. The blades are held in fir-tree serrations in the turbine disc and secured individually by tubular rivets. The blade tips rotate inside a double knife-edge shroud and form a continuous seal when the engine is running. This reduces tip leakage and increases turbine efficiency.

EXHAUST DUCT

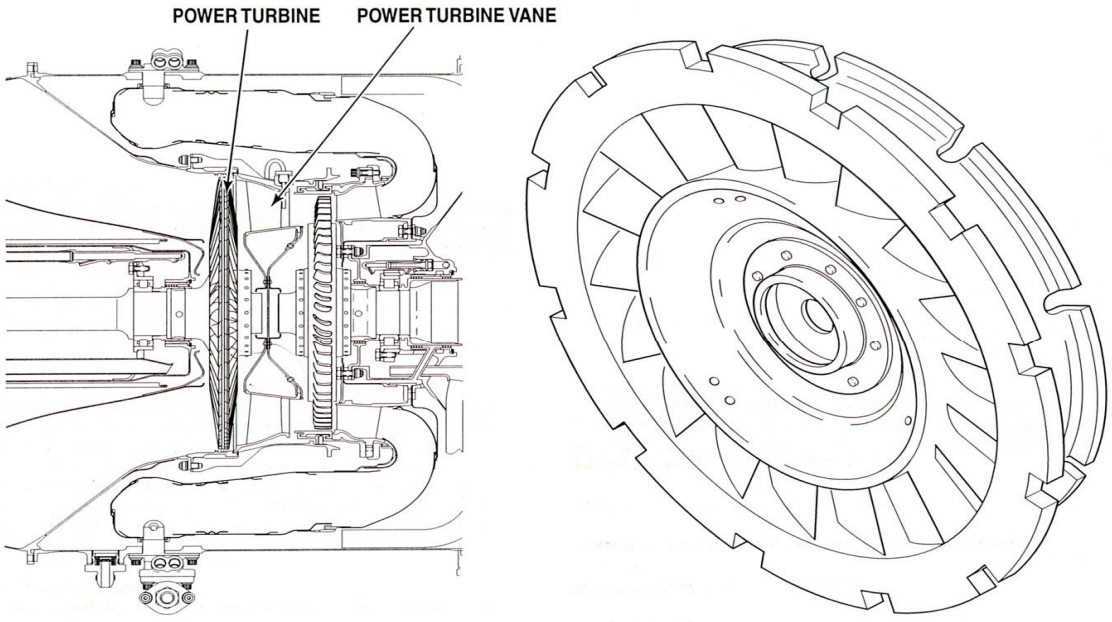
The exhaust duct consists of a divergent heat- resistant steel duct provided with two outlet ports, one on each side of the case (one outlet port on –50, -114 and T3). The duct is secured to the front flange of the gas generator case and comprises an inner and an outer section. The outer conical section, which has two flanged exhaust outlet ports, forms the outer gas path and also functions as a structural member to support the reduction gearbox. The inner section forms the inner gas path and provides a compartment for the reduction gearbox rear case and the power turbine support housing. A removable sandwich-type heat shield insulated the rear case and power turbine support housing from hot exhaust gases. A drain passage located at the 6 o'clock position at flange C allows residual fuel, accumulating in the exhaust duct during engine shutdown, to drain into the gas generator case and flow overboard.

NO.3 AND NO.4 BEARINGS

The power disc and shaft assembly is Supported and secured in the power turbine support housing by the No.3 roller bearing and the No.4 ball bearing. Both bearings have flanged outer races which are individually bolted to flanges inside the power turbine shaft support housing. The power turbine disc holds the No.3 bearing plain inner race interposed between a shoulder on the turbine and the No.3 rotating air seal on the rear end of the power turbine shaft. The No.4 bearing has a split inner race which is stacked between a shoulder on the turbine shaft, and a positioning ring and coupling secured by a cupwasher and spanner nut. A puller groove of the front half of the split inner race to facilitate removal.



POWER TURBINE NO.3 & NO.4 BEARING AREA



POWER TURBINE VANE RING

POWER TURBINE SUPPORT HOUSING

The power turbine support housing consists of a fabricated steel cylindrical housing attached to the reduction gearbox rear case by 12 studs. The housing provides support for the power turbine shaft assembly and two bearings. A labyrinth seal, secured at the rear of the housing by a retaining ring prevents oil leakage into the power turbine section. An internal oil transfer tube, fitted with four oil jets, provides front and rear lubrication to No.3 and No.4 bearings. A scavenge tube secured inside the housing at the 6 o'clock position, transfers bearing scavenge oil to the front of the engine.

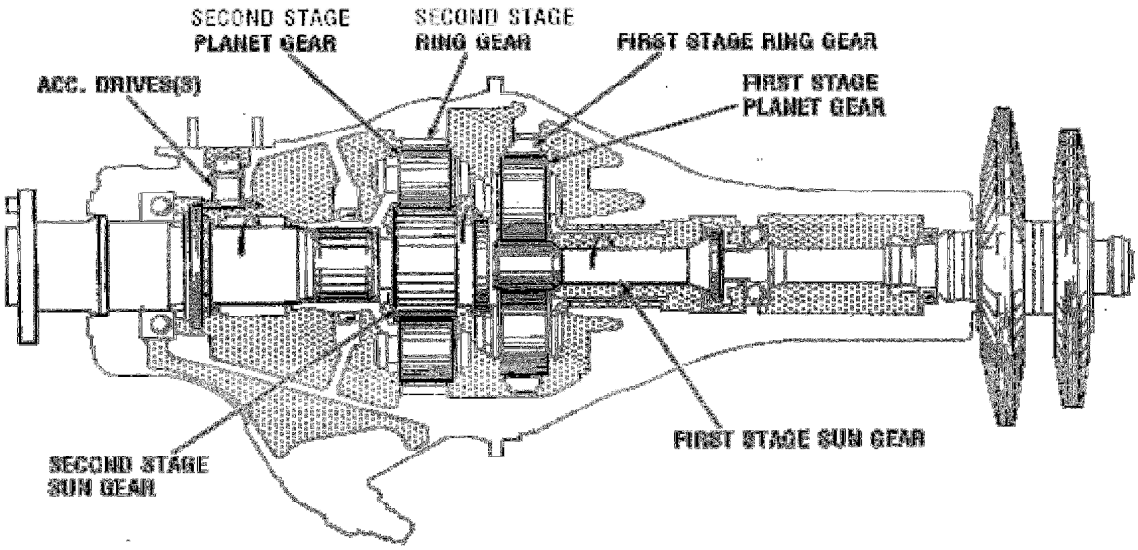
REDUCTION GEARBOX

The reduction gearbox is located at the front of the engine and consists of two magnesium (aluminum on some models) alloy castings bolted to the front flange of the exhaust duct. The first stage of reduction is contained in the rear case. Torque form the power turbine is transmitted through the power turbine shaft to the first stage sun gear.

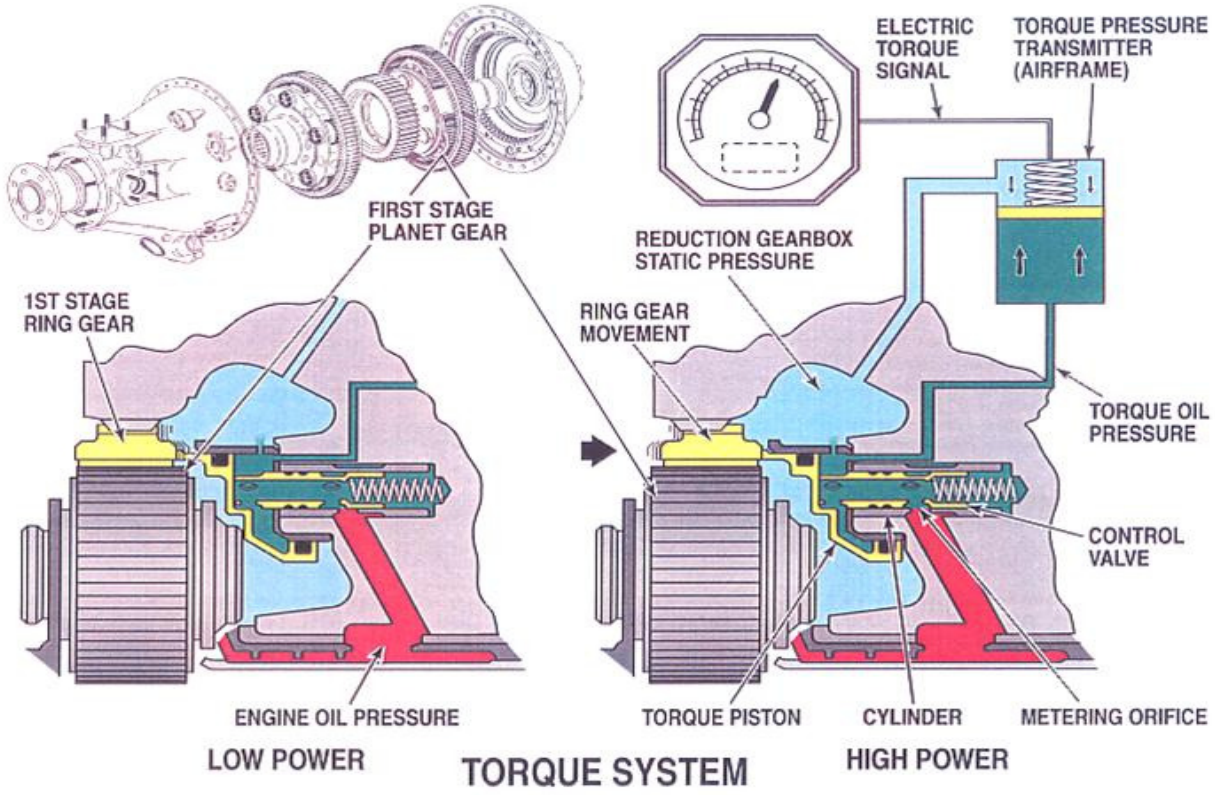
The sun gear consists of a short hollow steel shaft which has an integral spur gear at the front end and external splines at the rear. The external splines fit over the end of the turbine shaft and engage the internal splines of a retainer coupling. The coupling is in turn splined to the turbine shaft and secured there by a retaining nut and cupwasher. Two snap rings secure the sun gear in the retainer coupling. The spur gear end of the sun gear drives the three planet gears in the first stage planet carrier.

The first stage ring gear is located in helical splines provided in the rear case of the reduction gearbox. The torque developed by the power turbine is transmitted through the sun gear and planet gears to the ring gear which is opposed by the helical splines, resulting in rotation of the planet carrier. The ring gear, through held by the helical splines, can move axially between the case and three retaining plates. This movement is used in the torquemeter application.

The second stage of reduction is contained in the reduction gearbox front case. The first stage planet carrier is attached to the second stage sung ear b a flexible coupling which serves to dampen any vibrations between the two rotating masses and corrects for possible misalignment. The second stage sun gear drives five planet gears in the second stage carrier. A second stage ring gear is fixed by splines to the reduction gearbox front case and secured by three bolted retaining plates. The second stage carrier is in turn splined to the propeller shaft and secured by a retaining nut and shroud washer. A flanged roller bearing assembly, secured by four bolts to the front case, provides radial support for the second stage carrier and propeller shaft. An oil transfer tube and nozzle assembly, fitted with preformed packings, is secured within the propeller shaft by a snap ring to provide lubrication to No.4 bearing and the first stage sun gear.



REDUCTION GEARBOX STANDARD ROTATION



The accessories located on the reduction gearbox front case are driven by a bevel drive gear mounted on the propeller shaft behind the thrust bearing assembly. Propeller thrust loads are absorbed by a flanged ball bearing located in the front face of the reduction gearbox centerbore. The bevel drive gear, adjusting spacer, thrust bearing and seal runner are stacked and secured to the propeller shaft by a single spanner nut and keywasher. The thrust bearing cover is secured to the front of the reduction gearbox and incorporated a removable retaining ring to facilitate replacement of the oil seal.

TORQUEMETER

The torquemeter is a hydro-mechanical torque measuring device located inside the rear reduction gearbox housing which provides an accurate indication of engine power output. The mechanism consists of a cylinder, piston, seals, valve plunger and spring.

Rotation of the first stage ring gear is resisted by the helical splines which imparts an axial movement to the ring gear and, therefore, to the piston face. This in turn moves a valve plunger against a spring, opening a metering orifice and allowing an increased flow of pressure oil to enter the torquemeter chamber. This movement continues until the oil pressure in the torque chamber is proportional to the torque being absorbed by the ring gear. Any change in power lever setting recycles the sequences until a state of equilibrium is again reached.

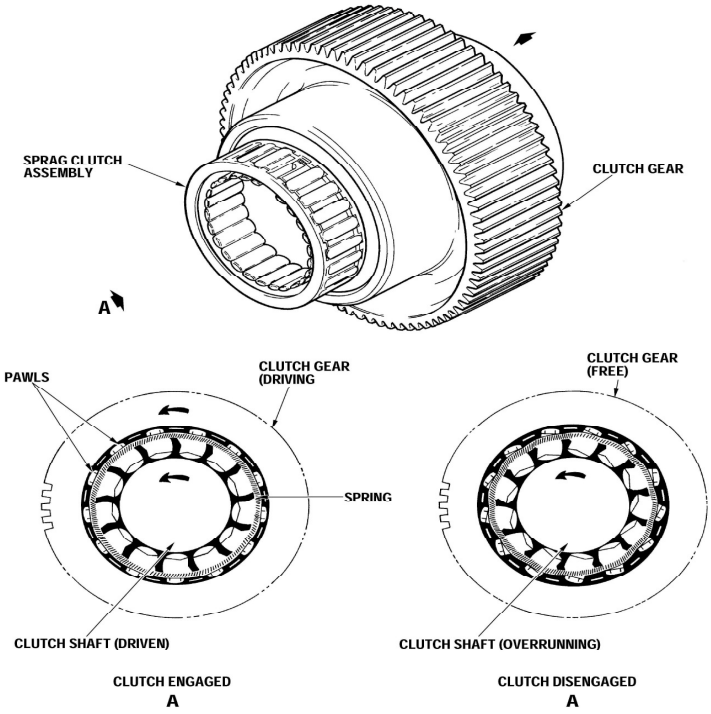
A hydraulic lock is prevented by a continuous oil bleed from the pressure chamber into the reduction gear casing through a small bleed hole in the cylinder.

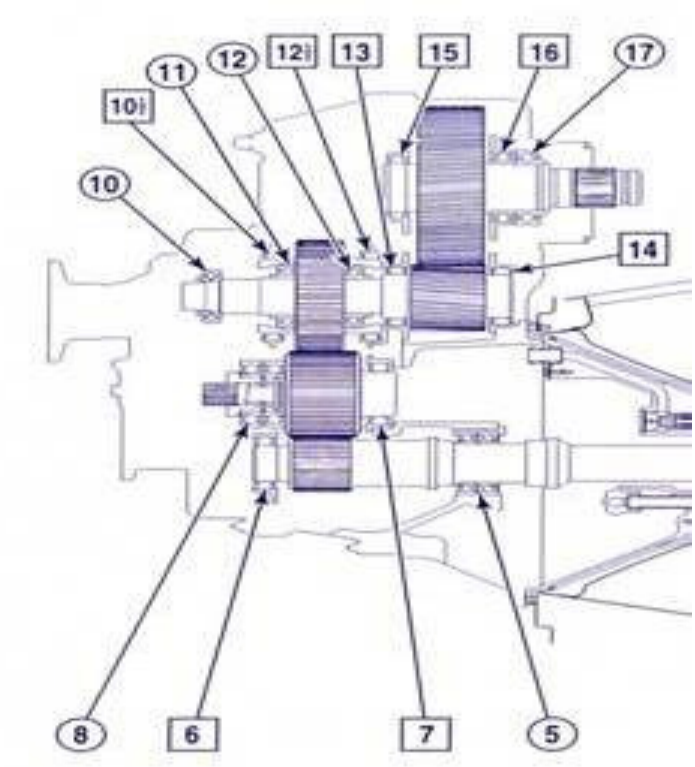
Because the external pressure and the pressure within the reduction gearbox may vary and affect the total pressure on the torquemeter piston, the internal gearbox pressure is measured. The difference between the torquemeter pressure and the reduction gearbox internal pressure accurately indicates the torque being produced. The two pressures are routed through cast passages to bosses located on the top of the reduction gearbox front case where connections can be made to suit individual cockpit instrumentation requirement.

COMBINED GEARBOX (TWIN PAC)

This module is made of two input sections and one output section. Each input section has an integral torquemeter, similar to the ones on the A models, one tacho generator, one power turbine (Nf) governor and one Pg air pressure accumulator. The housings have platforms for the oil coolers fan.

The input section has a three stages reduction gear train that provides a reduction ratio of 5:1. The combined gearbox housing is made of 5 parts: the input housing, the output housing, a diaphragm and two covers which provide mounting pads for the accessories. The output housing has flange “A” where the power sections mate. All these parts are assembled with bolts and guide pins, to provide a good alignment of the bearings.


SPRAG CLUTCH ASSEMBLY
CLUTCH GEAR
A
PAWLS
CLUTCH GEAR (DRIVING
SPRING
CLUTCH GEAR (FREE)
CLUTCH SHAFT (DRIVEN)
CLUTCH SHAFT (OVERRUNNING)
CLUTCH ENGAGED
A
CLUTCH DISENGAGED
A


11
12
12i
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The second stage gear transmits the rotation to the third stage thru a gear that is couple to its shaft with a clutch. An extension of the second stage passes the rotation for the oil cooler fan, the tacho generator and the power turbine (Nf) governor.

The clutch works in such a way that when the engine has power the second stage gear transmits movements to the third stage helical gear, which in turn rotates the output gearshaft.

In the event that one power section stops transmitting power, the clutch disengages the helical gear from the second stage gear. This is similar to the pedals on a bike when the cyclist does not apply any force.

The output gearshaft rest at the rear on the No.15 roller bearing (on the diaphragm) and at the front on the No.16 roller bearing and No.17 ball bearing (on the output housing). In the rear, the shaft has an extension that moves the oil pump for the output section.

COMBINED GEARBOX TORQUEMETER

When there is a change in output power, the output helical gear produces an axial movement on the third stage gearshaft. The force that produces this displacement is balanced by the pressure on the inside of the torquemeter cylinder which changes according with the position of the torque meter valve. The pressure of the oil inside the torquemeter is proportional to the engine power and it is used to provide an external indication of such parameter. Also this pressure is sent to the torque control unit which acts as a torque equalizer between power sections and torque limiter.

ACCESSORY GEARBOX

The accessory gearbox housing is located at the rear of the engine and is comprised of two magnesium alloy (aluminum on some models) castings which are secured by their joint flanges to studs on the rear flange of the compressor inlet case. The front casting, provided with front and rear preformed packings forms an oil-tight diaphragm between the oil tank compartment of the inlet case and the accessory drives. The diaphragm also provides support for the accessory drive gear bearings, seals and the main oil pressure pump which is bolted to the front. The diaphragm is secured to the accessory gearbox housing by four countersunk screws and nuts.

The rear casting forms an accessory gearbox cover and provides support bosses for the accessory drive bearing and seals.
The internal scavenge oil pump is secured inside the housing, and a second scavenge oil pump is externally mounted. Mounting pads and studs are provided on the rear face for the combined starter-generator, the fuel control unit with the sandwich mounted fuel pump and the Ng tachometer-generator. A large access plug, located

below the starter generator mounting pad, provides passage for a puller tool which must be used to disengage and

hold the ball-locked coupling shaft and input gearshaft during disassembly.

Three additional pads are available for optional requirements. All accessory drives are supported on identical roller bearings fitted with garter type oil seals.

An oil tank filler cap and dipstick is located at the 11 o'clock position on the gearbox cover to facilitate servicing of the oil system. An oil tray is incorporated in the lower section of the gearbox, adjacent to the scavenge pump drive gears, to prevent oil foaming during operation.

A centrifugal oil separator, mounted on the starter-generator drive gearshaft, separates the oil from the engine breather air in the accessory gearbox housing. A cored passage in the accessory diaphragm connects the oil separator to an external mounting pad located at the 2 o'clock position on the rear housing. A carbon-face seal located in front of the gearshaft in the accessory diaphragm prevents pressure leakage through the baring assembly.

AIR SYSTEMS GENERAL

The engine has three separate air systems: a compressor air bleed control, a bearing compartment air seal and breather system, and a hot section cooling system. Two optional sources of high pressure air are also provided. One source bleeds P2.5 compressor air from the gas generator case at the 1 o'clock position. The second source

provides P3 air from the gas generator case at the 11 o'clock position. Either or both may be blanked off, depending on installation requirement.

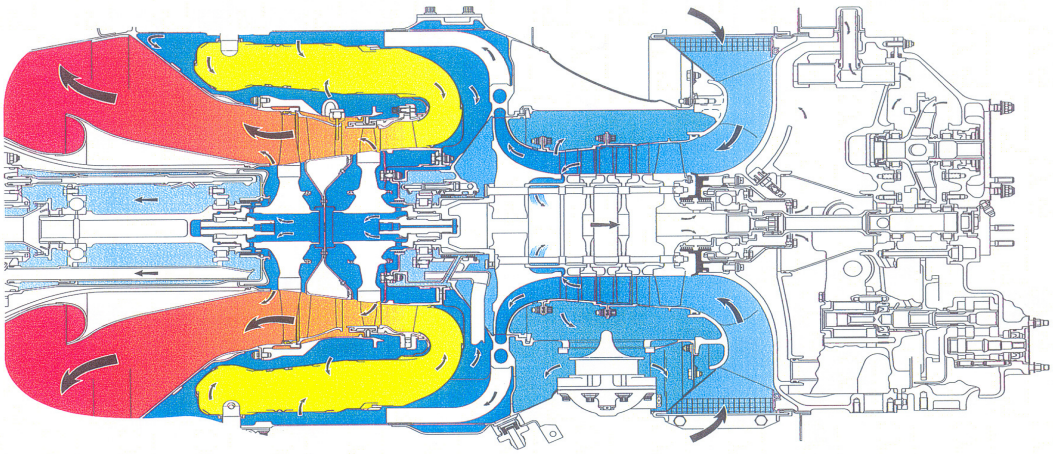
COMPRESSOR BLEED VALVE

The compressor bleed valve automatically opens a port in the gas generator case to spill interstage compressor air (P2.5), there by providing anti-stall characteristics at low engine speeds. The port closes gradually as higher engine speeds are attained. On later engine models, two valves are used to bleed excess air at two different speed ranges.

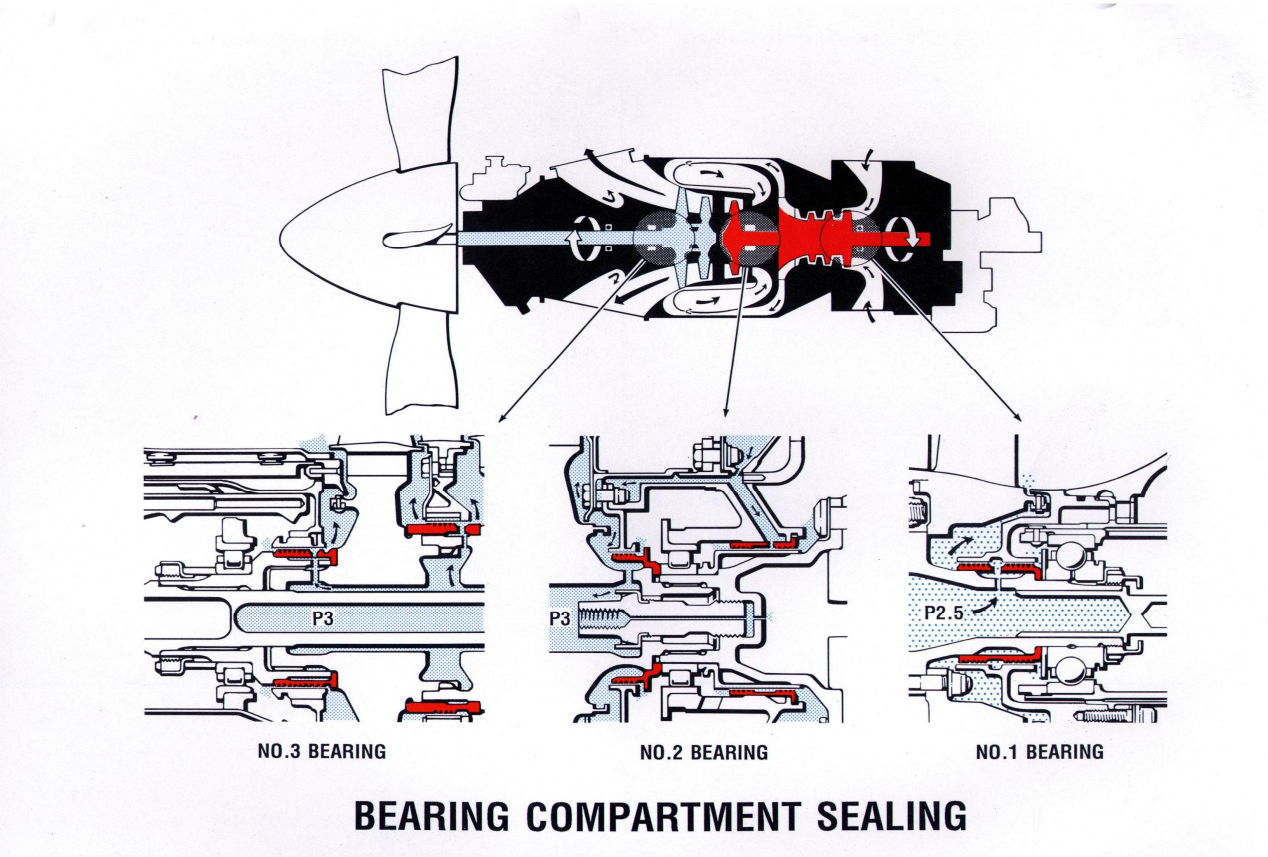
The compressor bleed valve, located on the gas generator case at the 7 o'clock (varies by application) position and secured by four bolts, consists of a piston type valve in a ported housing. The piston is supported in the bore of the housing by rolling diaphragm which permits piston full travel in either direction to open or close the ports while, at the same time, effectively sealing the compartment at the top of the piston. A port in the gas generator case provides a direct passage for the flow of compressor interstage air (P2.5) to the bottom of the bleed valve piston.

Compressor discharge air (P3) is tapped off and metered through a fixed orifice in the body of the unit, then across the top of the piston and out to

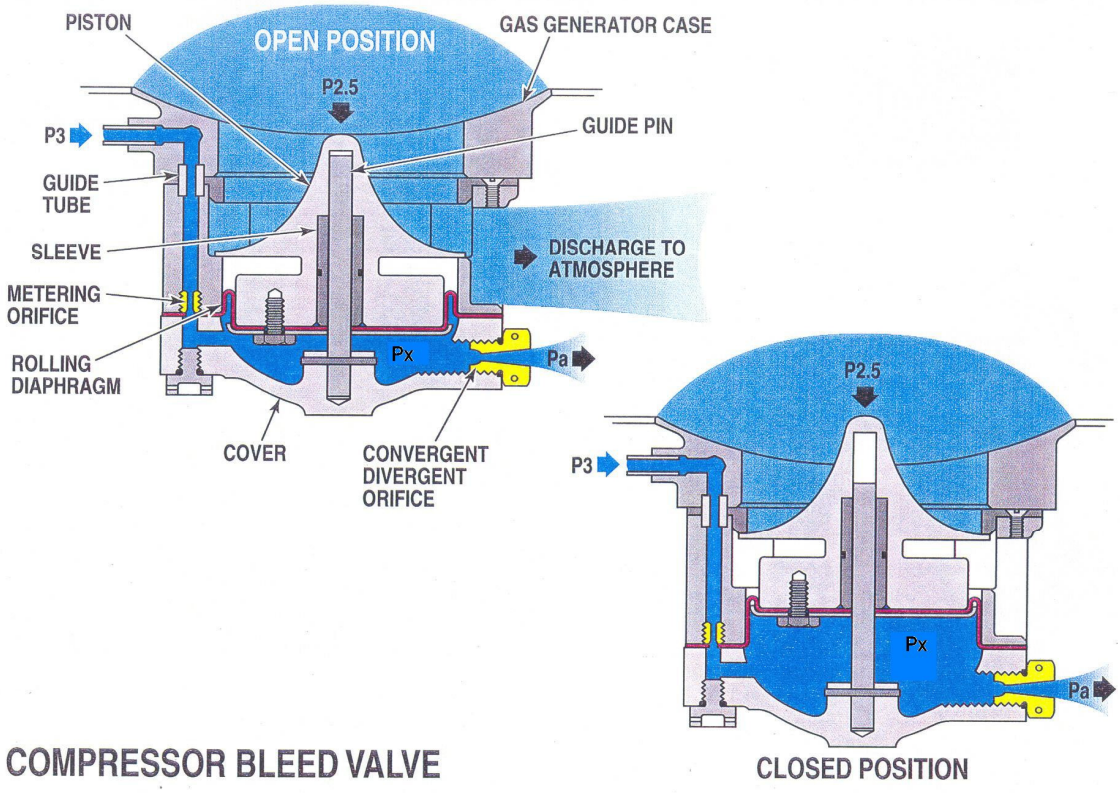
atmosphere through a metering plug (convergent/divergent orifice). The control pressure Px between the two orifices acts upon the upper side of the bleed valve piston, so that when Px is



SECONDARY AIR SYSTEM

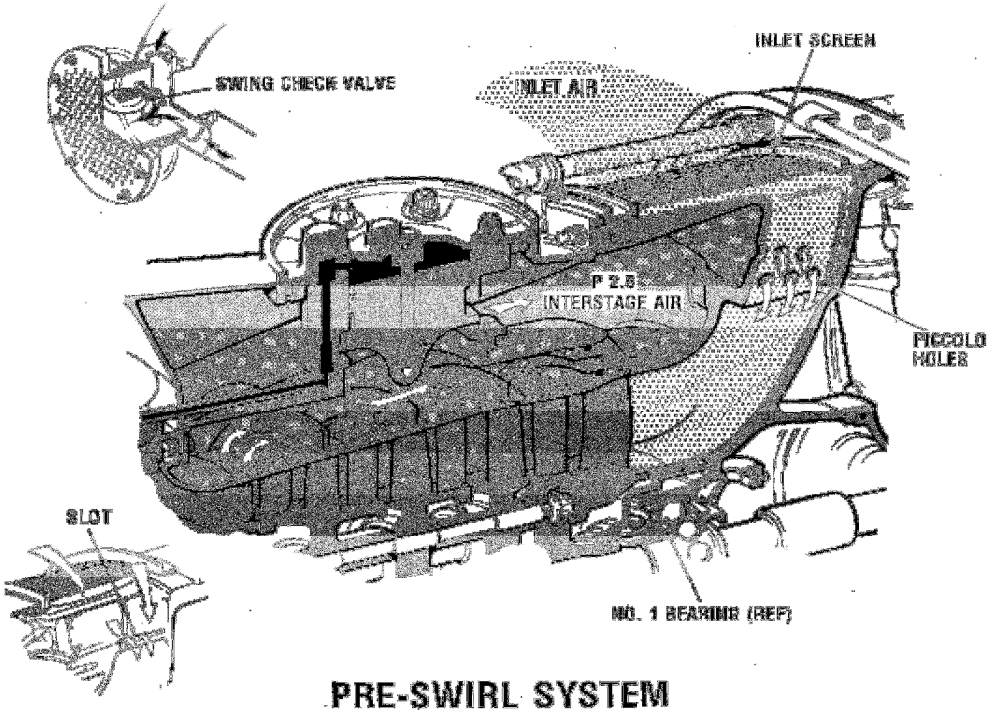


BEARING COMPARTMENT SEALING



COMPRESSOR BLEED VALVE

CLOSED POSITION



PRE-SWIRL SYSTEM

greater than P2.5, the bleed valve closes. In the closed position, the port is sealed off by the piston which is forced against its seat by the action of Px. Conversely, when Px is less than P2.5, the bleed valve opens and allows interstage (P2.5) to discharge to atmosphere.

BEARING COMPARTMENT SEALS, TURBINE COOLING AND AIR BLEED SYSTEMS

Pressure air, in conjunction with air seals, is utilized to seal the first, second, and third bearing compartment, and also to cool both the compressor and power turbine parts. The air seals, which establish and control the required pressure gradients, comprise two separate parts: the inner part housing a plain rotating surface; the outer stationary part consisting of a series of expansion chambers (labyrinths) formed by deep annular grooves machined in the bore of the seal. A minimum clearance, consistent with mechanical safety, is maintained between the inner rotating, and the outer stationary parts of the seal.

Compressor inter-stage air is utilized to provide a pressure drop across the labyrinth seal located in front of No.1 bearing. The air is led through perforations in the rim of the third stage compressor spacer into the center of the rotor. It then flows rearward through passages in the three compressor discs, and in the compressor rear hub; to an annulus in the center of the air seal where it is leaked through the labyrinth to provide the required pressure seal.

The No.2 bearing is protected by a single air seal at the front and a double seal at the rear of the bearing. (The reverse is true in PT6A-6 and –20 engines). Pressure air for this system is bled either from the centrifugal impeller tip or, depending on engine speed, from the cavity behind the large exit duct. The air flows through passages in the No.2 bearing support, equalizing the air pressure at the front and rear of the bearing compartment, to ensure a pressure seal in the front and rear labyrinth. The No.2 bearing cavity seal air is vented into the accessory gearbox through the oil scavenge line.

The compressor and power turbine discs are both cooled by compressor discharge air bled form the diffuser exit zone down the rear face of the outer exit duct. It is then metered through holes in the cover of the compressor turbine bearing housing where it divides into three paths. Some of the air is metered to cool the rear face of the compressor turbine disc and some to pressurize the bearing seals. The balance is led forward through passages in the compressor turbine disc hub. Some is used to cool the front face of the compressor turbine a portion of this cooling air is also led through a hole in the center of the interstage baffle to the rear face of the power turbine disc. The remainder passes forward through the center of the power

turbine disc, out through drilled passages in the hub to pressurize the No.3 bearing air seals, and on the cool the front face of the disc.

The cooling air from both of the turbine discs is dissipated into the main gas stream flow to atmosphere. The bearing cavity leakage air is scavenged with the oil into the accessory gearbox and vented to atmosphere through the centrifugal breather.

LUBRICATION SYSTEM GENERAL

The lubrication system is designed to provide a constant supply of clean lubricating oil to the engine bearings, reduction gears, torquemeter, propeller and all accessory drive gears. The oil lubricates and cools the bearings, and conducts any foreign matter to the main oil filter where it is separated from the oil flow. Calibrated oil nozzles are used on the main engine bearings to ensure that an optimum oil flow is maintained for all operating conditions. A main pressure pump located in the oil tank supplies oil to the accessory section and, through an external transfer tube, to the gas generator section and reduction gearbox.

OIL TANK

The oil tank is an integral part of the compressor inlet case and is located in front of the accessory gearbox. The oil tank is provided with an oil filler neck and a quantity dipstick and cap which protrude through the accessory gearbox housing at 11 o'clock. The markings on the dipstick correspond to US quarts and indicate the quantity of oil required to top the tank to the full mark. An anti-flooding and breather arrangement, located in the highest point of the oil tank, prevents flooding of the accessory gearbox in the event that the oil tank is overfilled. A drain plug in the bottom of the tank facilitates drainage.

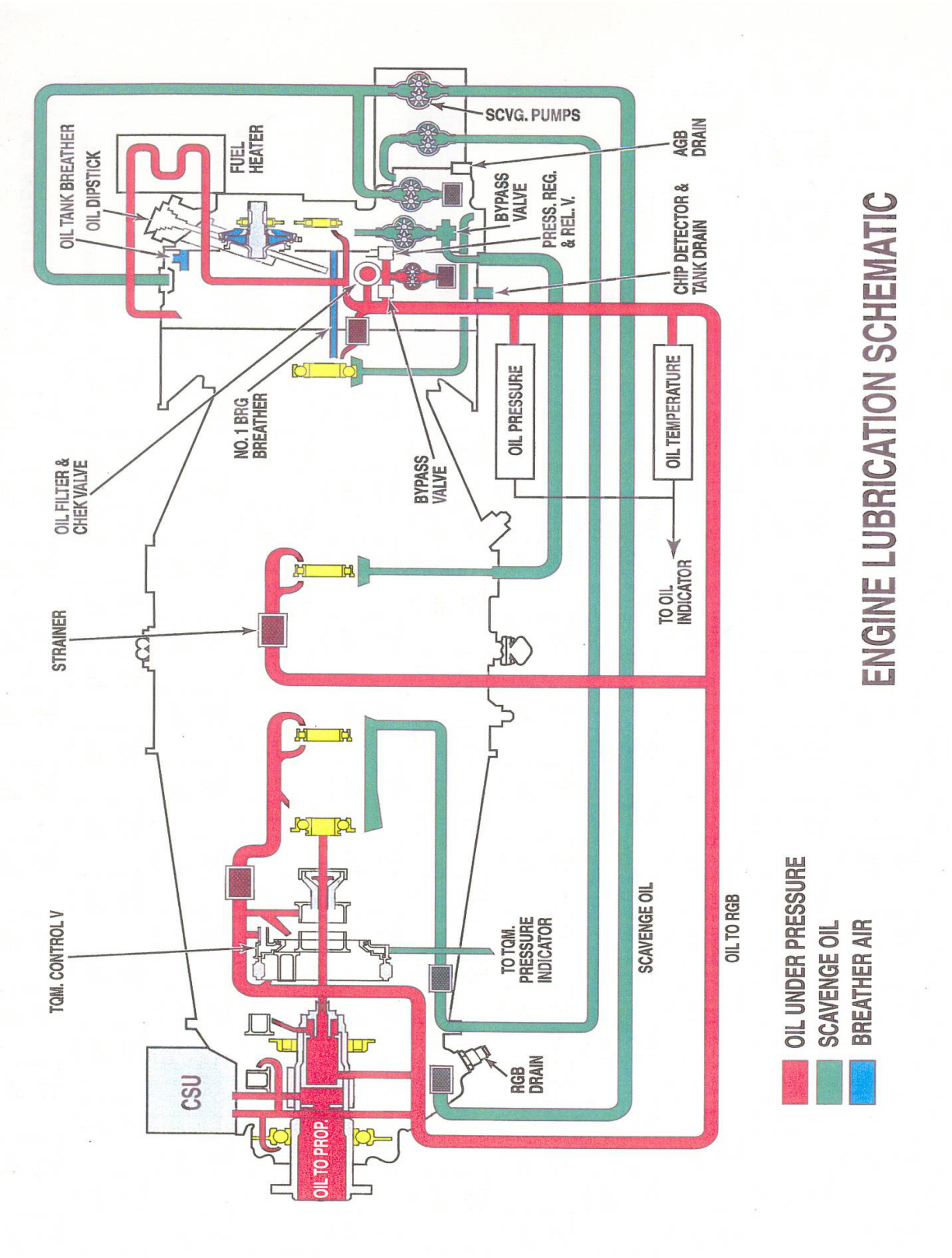
OIL PUMP

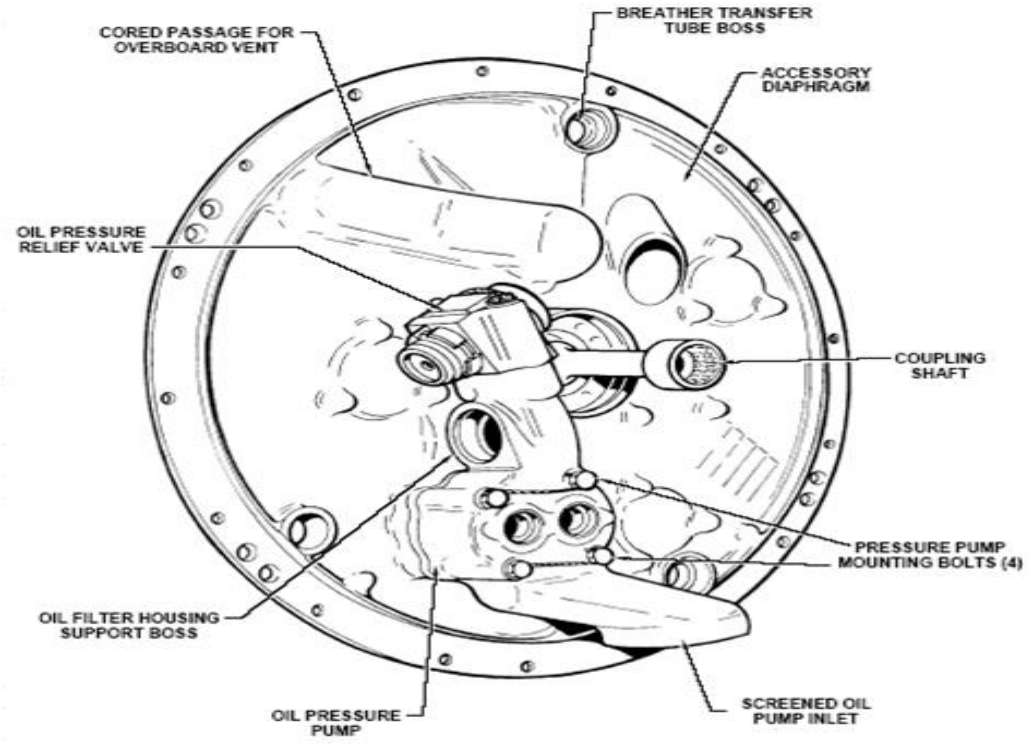
Pressurized oil is circulated form the oil tank, through the engine lubricating system, by a self-contained gear type pressure pump located in the lowest part of the oil tank. The oil pump comprises two gears, contained in a cast magnesium alloy housing which is bolted to the front face of the accessory diaphragm, and is driven, through the gearbox diaphragm, by an accessory drivegear. The oil pump body incorporated a circular mounting boss to accommodate the filter housing accessory. A second mounting boss on the pump accommodated the pressure relief valve on later model engines. Earlier engines have the pressure relief valve located in a cast boss at 2 o'clock on the inlet case.

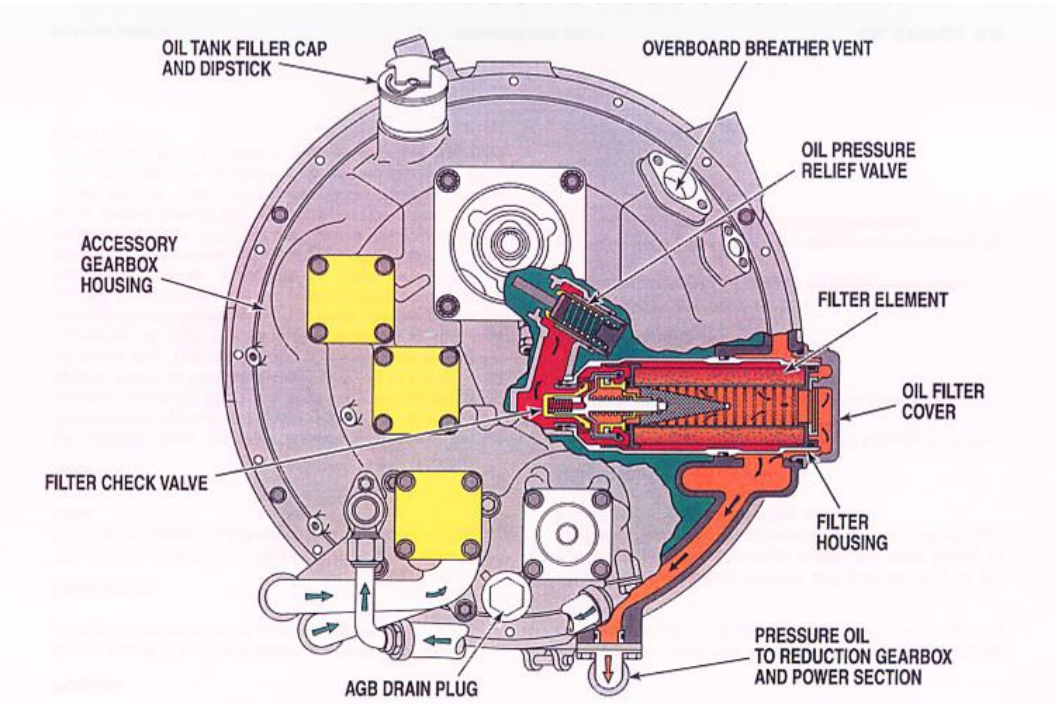
OIL FILTER ASSEMBLY

The oil filter assembly is located in the compressor inlet case at the 3 o'clock position. The assembly comprises a filter housing accommodating a disposable metal screen cased filter element with a perforated flange, a spring-loaded bypass valve and a check valve. The disposable filter element is

formed by an outercore main filter screen and a centercore coarse conehat type bypass filter screen. Some cleanable filters are still in use.


ENGINE LUBRICATION SCHEMATIC
SCVG. PUMPS
AGB DRAIN
OIL TANK BREATHER
OIL DIPSTICK
FUEL HEATER
BYPASS VALVE
PRESS. REG. & REL. V.
CHIP DETECTOR & TANK DRAIN
OIL PRESSURE
OIL TEMPERATURE
NO. 1 BRG BREATHER
OIL FILTER & CHEK VALVE
BYPASS VALVE
STRAINER
TO OIL INDICATOR
TQM. CONTROL V
TO TQM. PRESSURE INDICATOR
SCAVENGE OIL
OIL TO RGB
CSU
RGB DRAIN
OIL TO PROP.
OIL UNDER PRESSURE
SCAVENGE OIL
BREATHER AIR


CORED PASSAGE FOR OVERBOARD VENT
BREATHER TRANSFER TUBE BOSS
ACCESSORY DIAPHRAGM
OIL PRESSURE RELIEF VALVE
COUPLING SHAFT
PRESSURE PUMP MOUNTING BOLTS (4)
OIL FILTER HOUSING SUPPORT BOSS
OIL PRESSURE PUMP
SCREENED OIL PUMP INLET



OIL PRESSURE REGULATION & FILTRATION

A filter cover, which is secured to the inlet case by four nuts, holds the filter element and housing in position. Pressure oil flows through the check valve into the housing, through the filter element and out to the engine system via a cored passage, leaving any foreign matter deposited on the exterior of the element.

The check valve, positioned in the end of the housing, prevents gravity flow into the engine after shutdown and permits the filter element to be changed without having to drain the oil tank.

A filter bypass is provided by a spring-loaded bypass valve located in the downstream side of the check valve. The bypass valve is normally closed and sealed against leakage by a moulded seal located on the front end of the filter element. In the event of a blocked filter, the increased pressure overcomes the bypass valve spring, opens the bypass valve and provides an alternative passage, through the coarse filter screen in the centercore of the filter element, for the oil flow through the engine.

PRESSURE OIL SYSTEM

The engine oil pressure is regulated by a removable plunger type pressure relief valve secured to the top of the

main oil pressure pump housing. All oil in excess of the regulated pressure is bypassed back to the tank upstream of the main oil filter. The pressure relief valve is secured in the relief valve housing by a retaining ring both of

which are accessible through the engine main filter port.

The oil pressure may be adjusted by the addition or deletion of spacers.

Lubrication of the accessory drives and bearings is supplied from the oil filter through cored passages and transfer tubes in the accessory diaphragm and rear gearbox housing. The No.1 bearing is lubricated by pressure oil, routed via an internal passage in the compressor inlet case, through a fine strainer and oil nozzle jet secured in the center section of the inlet case at the rear of the bearing. The oil is sprayed by the jet into a collector ring mounted on the end of the compressor hub, and directed through passages in the split inner race to the bearing assembly by centrifugal force.

A direct supply of oil is provided to lubricate the No.2 bearing, reduction gearbox, front accessories, and the power turbine shaft bearings. Front he filter, the oil is directed through a cored passage to an outlet boss at the bottom of the compressor inlet case. An external transfer tube, connected to the boss, leads pressure oil forward to the reduction gearbox. Oil is tapped front his tube to lubricate No.2 bearing via an internal transfer tube secured in the gas generator case.

The tube passes between two diffuser pipes to an oil gallery with two nozzles.

A fine strainer protects the two oil jets which are positioned one in front and one at the rear of the No.2 bearing. Pressure oil is delivered at 80 to 100 PSIG to the reduction gearbox where it is divided into three branches. One branch is fed to the first stage reduction

gears, splines, torquemeter is fed through a metering valve which controls the flow into the torquemeter chamber.

The position of the metering valve is dependent on the torquemeter piston which reacts in direct proportion to engine torque. In addition to the torquemeter, oil in this branch is directed via an internal transfer tube and strainer in the power turbine support housing to four nozzles. The first oil jet directs a stream of oil against the rear face of the first stage sun gear coupling. Oil splashing off this coupling lubricates the No.4 bearing from the front. The second oil nozzle is positioned in the rear of the No.4 bearing to ensure sufficient lubrication. The other two nozzles are located one in the front and the other in the rear of No.3 bearing to provide cooling and lubrication. Oil in this branch also lubricates the plain bearing which supports the first stage carrier and, by means of drilled passages inside the carrier, also lubricated the planet gears and bearings. The second branch delivers oil to the second stage reduction gears and also to the No.4 bearing I.D. Oil flow is directed to this bearing through an oil nozzle secured in the rear of the propeller oil transfer tube.

Passages in the split inner races of the bearing line up with a drilled annulus on the power turbine shaft to provide

access for centrifugal oil flow into the bearing assembly. The third branch provides oil through cored passages in the RGB front case tot he propeller governor unit, the accessory drive gears and the propeller thrust bearing. Oil mist

provided lubrication to the second stage carrier bearing.

SCAVENGE OIL SYSTEM

The scavenge oil system includes two double-element scavenge pumps connected by internal passages and lines to two main external transfer tubes. One pump is secured inside the accessory gearbox and the other is externally mounted. They are contained in separate housings and driven off accessory gearshafts.

Oil from the No.1 bearing compartment is returned by gravity through a cored passage to the bottom of the compressor inlet case, and then through a transfer tube in the oil tank and accessory diaphragm into the accessory gearbox. No.2 bearing oil drains into an external transfer tube, rearward to the bottom of the oil tank. It is then scavenged, through a cored passage in the accessory diaphragm, to the scavenge pump which pumps the oil into the accessory gearbox. Oil from the centrifugal breather, bearings and input gearshaft drains to the bottom of the accessory gearbox and scavenged from the gearbox, together with oil from No.1 and No.2 bearings, and scavenged oil from No.3 and No.4 bearings, by the rear element of the internal scavenge pump. The double-element internal scavenge pump is connected by a quillshaft to the main oil pump in the oil tank and drives an externally mounted tachometer – generator.

Oil from No.3 and No.4 bearing compartments is scavenged, via internal tubes, into the reduction gearbox sump, then rearward through

an external transfer tube, to the front element of the external scavenge pump. This pump also scavenges any reduction gearbox oil which drains rearward when the engine is in a high angle of climb attitude. The oil is then fed forward to the accessory gearbox, via a machined passage in the pump housing, and a deflector. Oil from the propeller governor, front thrust bearing reduction gears and the torquemeter bleed orifice drains into the reduction gearbox sump and is then scavenged by the rear element of the external scavenge pump, via a second external transfer tube which extends rearward to the accessory housing. The oil from both internal and external scavenge pumps is forced through a T-fitting into a common line to an airframe oil cooler, form where it is returned to the oil tank via a deaerator tray in the top of the tank.

BREATHER SYSTEM

Breather air from the engine bearing compartments and the accessory gearbox is vented overboard through a centrifugal breather impeller located in

the accessory gearbox. The various engine compartments are connected to the accessory gearbox by cored passages or existing oil scavenge

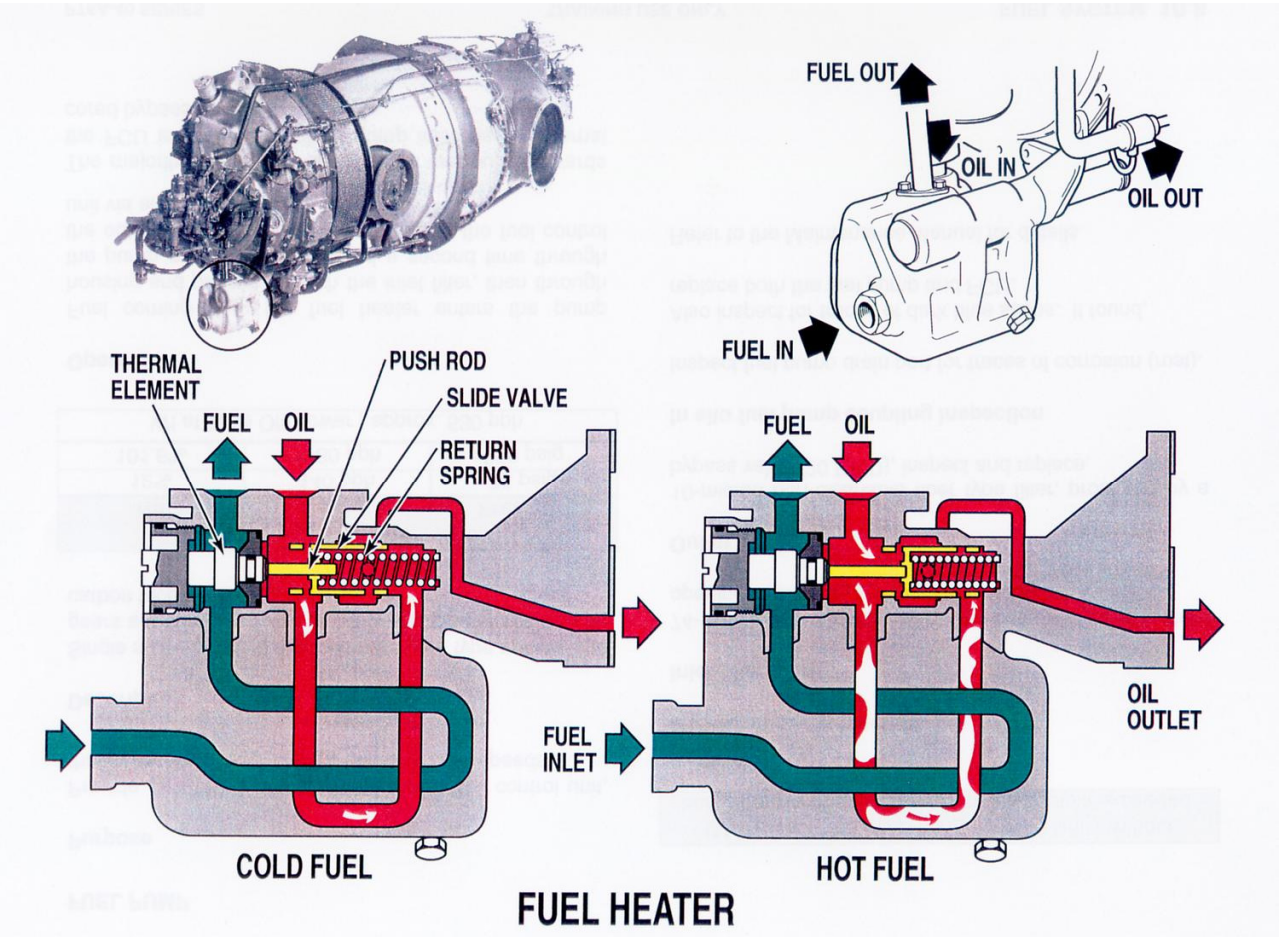
transfer tubes. The No.1 bearing vents rearward through the bearing rear housing and the oil tank center tube, into the accessory gearbox through its oil scavenge tube and sump arrangement. A bypass valve, immediately upstream of the front scavenge pump, vents to the accessory gearbox when the engine is running at

high power. The No.3 and No.4 bearings and reduction gearbox are vented, utilizing the internal and external scavenge tubes leading back from the reduction gearbox to the external oil scavenge pump mounted on the accessory gearbox, and dump into the oil tank via the airframe oil cooler. Equalization of air pressure between the oil tank and accessory gearbox is provided by a breather tube. This arrangement also prevents transfer of oil from tank to accessory gearbox during aircraft maneuvers with engine in changing attitudes. The oil tank in turn vents into the accessory gearbox through its anti-overfilling arrangement.

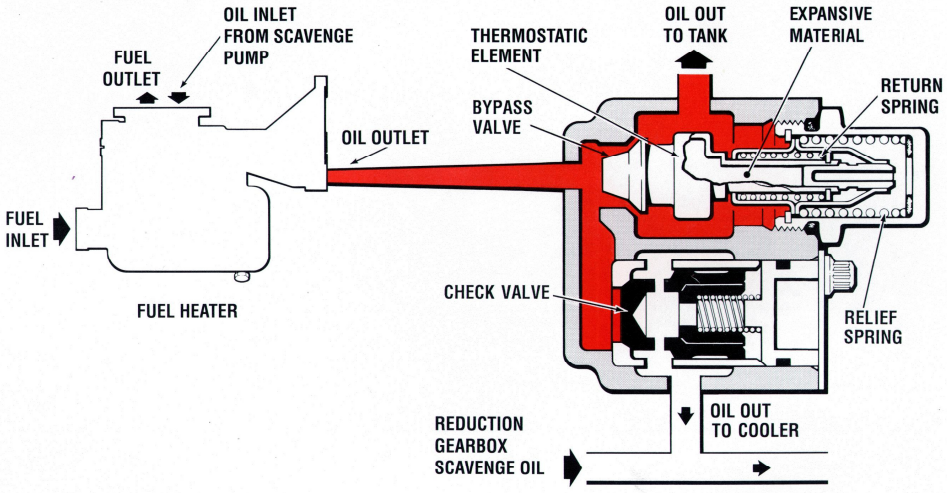
CENTRIFUGAL BREATHER

The centrifugal breather consists of an shrouded aluminum alloy impeller secured to the rear face of the starter-generator gearshaft by a retaining ring. Rotational torque is transmitted from the gearshaft to the impeller by three equi-spaced alloy pin. Breather air flows radial inward through the rotating impeller housing where the oil particles are separated from the air mist by centrifugal force. The oil particles are thrown outward and drain freely to the bottom of the accessory gearbox. The relatively oil-free breather air passes forward through the hollow center section of the gearshaft to a cored passage in the accessory diaphragm.

It is then routed through a transfer tube to a breather boss on the rear face of the accessory gearbox housing where a connection for an overboard vent line is provided.



FUEL HEATER



THERMOSTATIC BYPASS AND CHECK VALVE

OIL-TO-FUEL HEATER

The oil-to-fuel heater assembly utilizes heat from the engine oil system to preheat the fuel in the engine fuel system, and incorporates a multiple-pass oil circuit and a two pass fuel flow. A minimum pressurizing valve is fitted in a port at the 2 o'clock position on the inlet side of the oil-to-fuel heater. The valve closes at approximately 40 PSIG to prevent oil flow to the heater when the engine is shut down in flight with the propeller windmilling. A check valve on the outlet side of the heater is incorporated in the rigid oil return line to the top of the oil tank. A fuel temperature sensing oil bypass valve regulates the fuel temperature by either permitting oil flow through the heater core, or bypassing it through the valve to the engine oil tank via an external line.

The thermal element, which senses fuel temperature, consists of a highly expansive material sealed in a metallic chamber. The expansion force is transmitted through a diaphragm and plug to a piston. Since the element exerts an expansive force only, it is counterbalanced by a spring which provides a contracting force during decreases in temperature. The element senses outlet fuel temperatures and, at temperatures above 21C (70F), starts to close the core valve and simultaneously opens the bypass valve at 32C (90F), the core valve is completely closed and the oil bypasses the heater core.

OIL SYSTEM INSTRUMENTATION

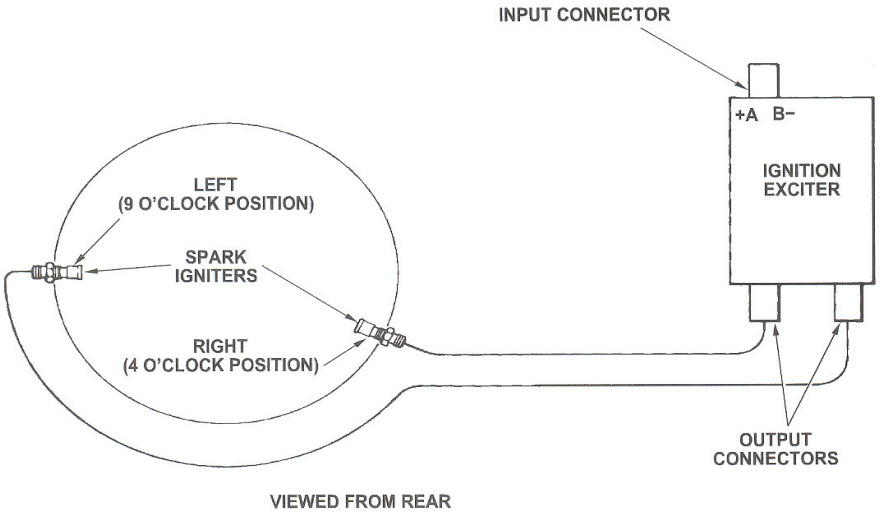
Main oil pressure is measured form the transmitter located at the 3 o'clock position on the accessory housing. The normal oil pressure range is 80 to 100 PSIG. Oil outlet temperature is detected by a temperature bulb located at the 4 o'clock position on the accessory gearbox.

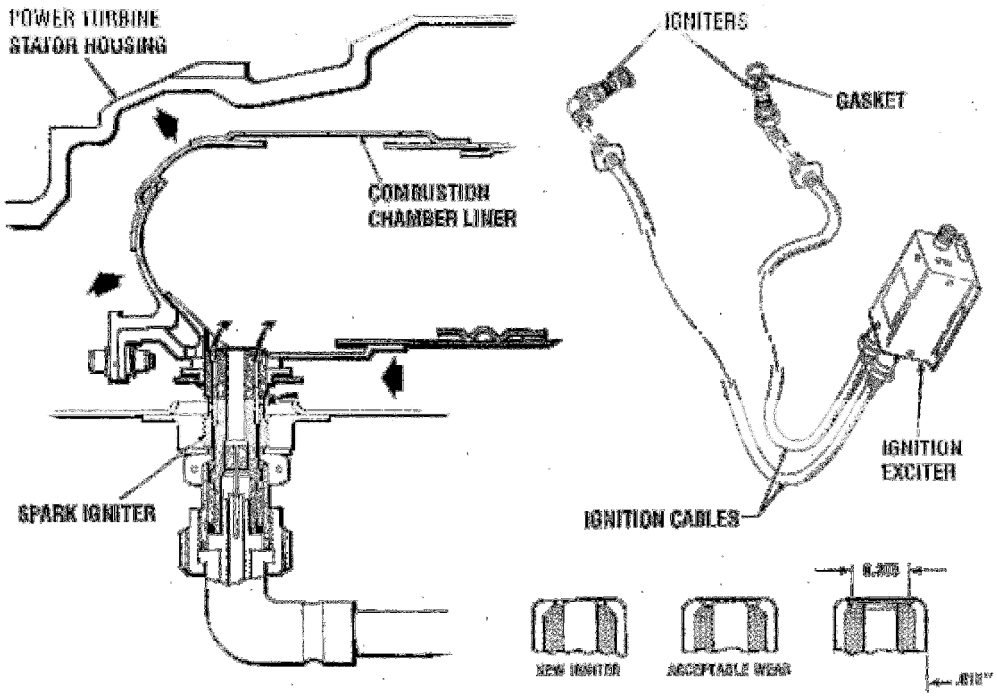
IGNITION SYSTEM GENERAL

The ignition consists of an ignition exciter unit, two spark igniters and two shielded leads.

IGNITION EXCITER UNIT

The exciter unit is mounted similar to the current regulator. It converts DC input to high energy output (8KVA) via solid state circuitry comprising a series of transformers, diodes and a storage capacitor. When the energy in the storage capacitor reaches a level equivalent to four joules, an internal spark gap in the exciter arcs and allows the stored energy to be discharged to the igniters through a dividing and circuit protection transformer network. The network is such that if one igniter is inoperative, the remaining igniter will continue to function.


INPUT CONNECTOR
+A B−
IGNITION EXCITER
LEFT (9 O'CLOCK POSITION)
SPARK IGNITERS
RIGHT (4 O'CLOCK POSITION)
OUTPUT CONNECTORS
VIEWED FROM REAR



IGNITION SYSTEM

SPARK IGNITERS

The spark igniters are mounted in the gas generator at 9 and 4 o'clock. A semiconductor material is incorporated in the igniter, as a shunt between center electrode and ground electrode (shell). As the potential across the electrodes increases, a small amount of current passes across the shunt; this current increases until air in the annular gap ionizes and high energy discharges across the electrodes, producing a spark to ignite the atomized fuel in the combustion chamber.

FUEL CONTROL SYSTEM

The fuel control system consists of three separate units with interdependent functions: the Fuel Control Unit (FCU), a Propeller Governor and a Starting Flow Control. The FCU determines the proper fuel schedule for engine steady state operation and acceleration/deceleration. The starting flow control acts as a flow divider, directing FCU metered fuel output to the primary fuel manifold or to both primary and secondary manifolds as required. Full propeller control during forward and reverse thrust operation is provided by a governor package which contains a normal propeller control during forward and reverse operation is provided by a governor package which contains a normal propeller governor (CSU) section, a reversing valve, and a power turbine governor section (Nf), (in

early engine models this function is provided by a separate unit).

The Nf governor section provides power turbine overspeed protection during

normal operation. During reverse thrust operation the propeller governor is inoperative and control of power turbine speed is accomplished by the Nf governor section.

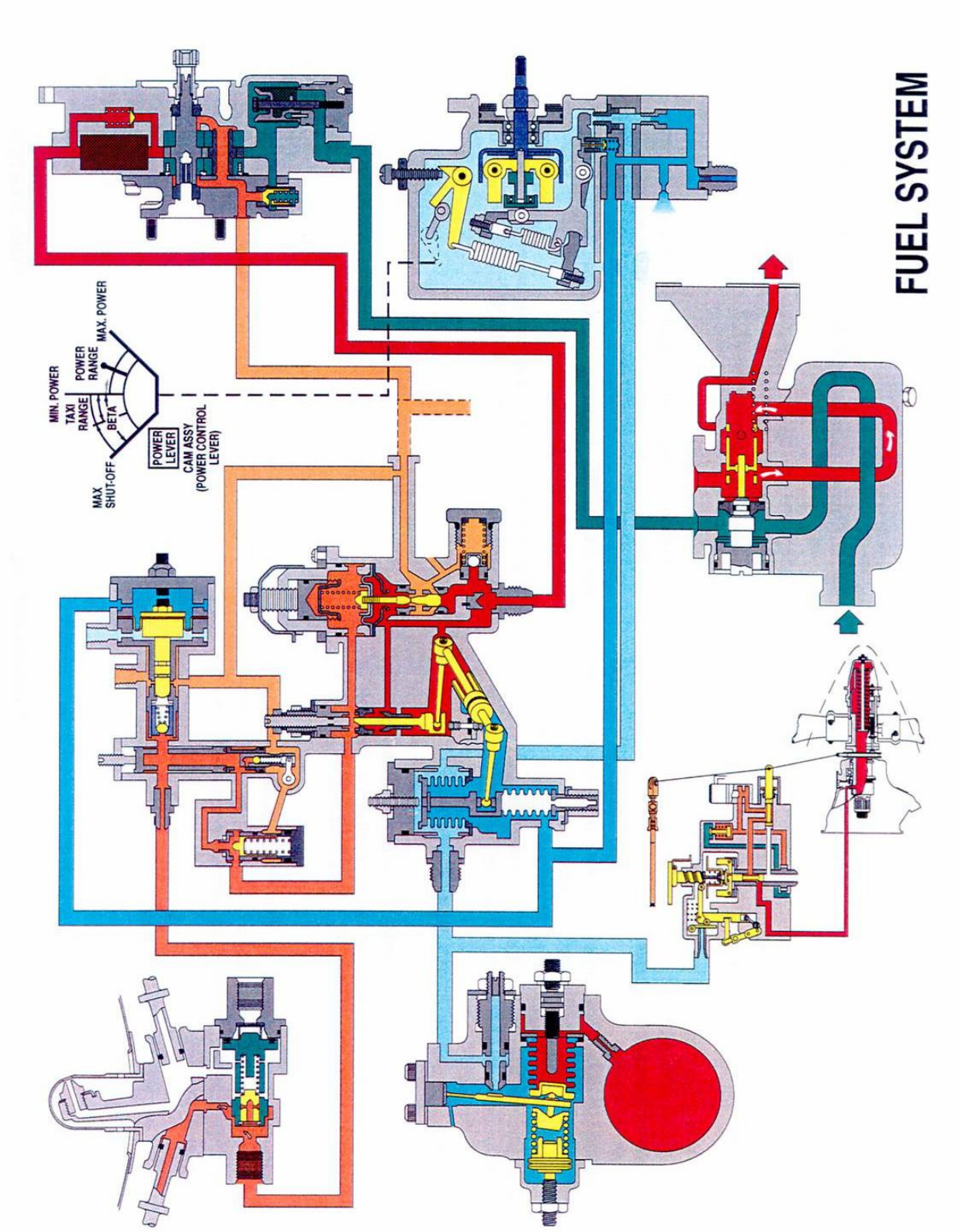
FUEL CONTROL UNIT GENERAL

The fuel control unit (FCU) is mounted on the engine driven fuel pump and is driven at a speed proportional to compressor turbine speed (Ng). The FCU determines the fuel schedule for the engine to provide the power required as established by the power lever. This is accomplished by controlling the speed of the compressor turbine (Ng).

Engine power output is directly dependent upon compressor turbine speed. The FCU governs Ng thereby actually governing the power output of the engine. Control of Ng is accomplished by regulating the amount of fuel supplied to the combustion section of the engine.

FUEL SECTION

The FCU is supplied with fuel at pump pressure (P1). Fuel flow is established by a metering valve and bypass valve system. The fuel pressure, immediately after the metering valve is called metered fuel pressure (P2). The bypass valve maintains an essentially constant fuel pressure differential (P1-P2) across the metering valve. The orifice area of the metering valve changes to meet specific engine power requirements. Fuel pump output in excess of these requirements will be returned via


FUEL SYSTEM
MAX. POWER
POWER RANGE
MIN. POWER
TAXI RANGE
BETA
MAX SHUT-OFF
POWER LEVER
CAM ASSY (POWER CONTROL LEVER)

internal passages in the FCU and fuel pump to the pump inlet downstream of the filter. This returned fuel is referred to as Po. The bypass valve consists of a sliding valve working in a ported sleeve. The valve is actuated by means of a diaphragm and spring. In operation, the spring force is balanced by the P1-P2 pressure differential working on the diaphragm. The bypass valve will always be in a position to maintain the P1-P2 differential and bypass fuel in excess of engine requirements.

A relief valve is incorporated parallel to the bypass valve to prevent a build-up of excessive P1 pressure in the FCU. The valve is spring-loaded closed and remains closed until the inlet fuel pressure (O1) overcomes the spring force and opens the valve. As soon as the inlet pressure is reduced, the valve closes. The metering valve consists of a contoured needle working in a sleeve. The metering valve regulates the flow of fuel by changing the orifice area. Fuel flow is a function of metering valve position only, as the bypass valve maintains an essentially constant differential fuel pressure across the orifice regardless of variations in inlet or discharge fuel pressures.

An external adjustment is provided on the bypass valve spring cover to match accelerations between engines on multi-engine installations. Compensation for variations is specific gravity resulting from changes in fuel temperature is accomplished by the bimetallic discs under the bypass valve spring.

POWER INPUT, SPEED GOVERNOR AND ENRICHMENT SECTION

The power input shaft incorporates a cam which depresses an internal lever when the power is increased. A spring connects this cam follower lever to the governor lever. The governor lever is pivoted and one end operates against an orifice to form the governor valve. The enrichment lever pivots at the same point as the governor lever and has two extensions which straddle a portion of the governor lever so that after a slight movement a gap will close and then both levers must move together. The enrichment lever actuates a fluted pin which operates against the enrichment “hat” valve. Another, smaller, spring connects the enrichment lever to the governor lever. A roller on the arm of the enrichment lever contacts the end of the governor spool.

The speed scheduling cam applies tension to the governor spring through the intermediate lever which applies a force to close the governor valve. The enrichment spring between the enrichment and governor levers provides a force to open the enrichment valve. As the drive shaft revolves, it rotates a table on which the governor weights are mounted.

Small levers on the inside of the weights contact the governor spool. As Ng increases, centrifugal force causes the weights to apply increasing force

against the spool. This tends to move the spool against the enrichment lever. As the governor weight force overcomes the opposing spring force,

the governor valve opens and the enrichment valve closes. The enrichment valve will start to close whenever Ng increases enough to cause the weight force to overcome the force of the smaller spring. If Ng continues to increase, the enrichment lever will continue to move until it contacts the governor lever, at which time the enrichment valve will be fully closed. The governor valve will open if Ng increases sufficiently to cause the weight force to overcome the force of the larger spring. At this point the governor valve will be open and the enrichment valve closed. The main body incorporates a vent port which vents the inner cavity to atmospheric pressure (Pa). Modified compressor charge pressure, Px and Py, will be bled off to Pa when the respective enrichment and governor valves are open.

BELLOWS ASSEMBLY

The bellows assembly consists of an evacuated (acceleration) bellows and a governor bellows connected by a common rod. The end of the acceleration bellows opposite the rod is attached to the body casting. The accelerating bellows provides an absolute pressure reference. The governor bellows is secured in the body cavity and its function is similar to that of a diaphragm. Movement of the bellows is transmitted to the metering valve by a cross shaft and associated levers.

The cross shaft moves within a torque tube which is attached to the cross shaft

near the bellows lever. The tube is secured in the body casting at the opposite end by means of an adjustment bushing. Therefore, any rotational movement of the cross shaft will result in an increase or decrease in the force of the torque tube. The torque tube forms the seal between the air and fuel sections of the control. (The torque tube is positioned during assembly to provide a force in a direction tending to close the metering valve. The bellows act against this force to open the metering valve.) Py pressure is applied to the outside of the governor bellows. Px pressure is applied to the inside of the governor bellows and to the outside of the acceleration bellows.

For explanation purposes, the governor bellows is illustrated as a diaphragm. Py pressure is applied to one side of the “diaphragm” and Px is applied to the opposite side. Px is also applied to the evacuated bellows attached to the “diaphragm.” The force of Px applied against the evacuated bellows is cancelled by application of the same pressure on an equal area of the “diaphragm,” as the forces applied to the bellows section can be resolved into forces acting on the “diaphragm” only.

These forces are: Py pressure acting on the entire surface of one side: the

internal pressure of the opposite side(within the area of pressure cancellation); and Px acting on the remainder of that side. Any change in Py will have more effect on the "diaphragm" than an equal change in Px, due to the difference in effective area.

Px and Py vary with changing engine operating conditions as well as inlet air temperature. When both pressures increase simultaneously, as during acceleration, the bellows cause the metering valve to move in an opening direction. When Py decreases as the desired Ng is approached (for governing after acceleration), the bellows will travel to reduce the opening of the metering valve. When both pressures decrease simultaneously, the bellows will travel to reduce the metering valve opening because a change in Py is more effective than the same change in Px. This occurs during deceleration and moves the metering valve to its minimum flow stop.

POWER TURBINE (Nf) GOVERNOR

The propeller governor, mounted on the reduction gearbox of the engine, contains a normal propeller governor (CSU) section, a reversing valve and a power turbine governor section, driven at a speed proportional to power turbine speed (Nf). The Nf governor section provides power turbine overspeed protection during normal operation. The Nf governor section senses Py pressure through an external pneumatic line from the drive body adapter on the FCU to the governor. In the event of a power turbine overspeed condition, an air bleed orifice in the Nf governor section is opened by flyweight action to bleed off Py pressure through the governor. When this occurs, Py pressure acting on the FCU bellows decreases to move the FCU metering valve in a closing direction, thus reducing fuel flow. Reduction in fuel flow decreases Ng

speed and consequently Nf speed. The speed at which the air bleed orifice opens is dependent on the setting of the propeller governor control lever and the setting of the Nf air bleed link. Normally the air bleed orifice is opened at approximately 6% above propeller governor speed setting with the Nf governor air bleed link at maximum position, and at approximately 4% under propeller governor speed setting at minimum position. In reverse thrust the propeller reversing interconnect linkage resets the Nf governor air bleed link to a setting below the propeller governor control lever setting.

Power turbine speed (Nf), and hence propeller speed, is then limited by the Nf propeller speed, is then limited by the Nf governor and power supplied by the gas generator is reduced to allow a propeller speed approximately 5% under the speed set by the propeller governor.

STARTING FLOW CONTROL

The starting flow control consists of a ported plunger sliding in a ported housing. Rotational movement of the input lever is converted to a linear translation of the plunger through a rack and pinion engagement. Rigging slots

are provided at the 45 and 75 RUN positions. One of these positions, depending on the aircraft type is used to rig the system and to identify the cockpit lever position.

A minimum pressurizing valve, located at the inlet to the starting flow control, maintains a minimum pressure in the

FCU to ensure correct fuel metering. Two connections are provided to the dual manifolds which are interconnected via the transfer valve. This valve permits the primary manifold to fill initially for light-up and, as pressure increases in the control, the transfer valve opens, allowing fuel into the secondary manifold. When the lever is in the CUT-OFF AND DUMP (zero degree) position, the fuel supply to both manifolds is blocked off; at the same time drain ports are aligned (via porting in the plunger) with the dump port allowing the residual fuel in the manifolds to drain overboard. This prevents the fuel from being coked in the system due to heat absorption. Fuel entering the starting flow control during engine rundown is diverted through the bypass port to the fuel pump inlet.

When the lever is placed in the RUN position, the outlet port to No.1 manifold is uncovered and the bypass port is completely blocked off. As the engine accelerates, both the fuel flow and manifold pressure increase until the transfer valve opens and No.2 manifold fills. When No.2 manifold is filled, the total flow is increased by that amount now being delivered through the No.2 manifold is filled, the total flow is increased by that amount now being delivered through the No.2 system and the engine further accelerates to idle. When the lever is moved beyond the RUN position (45 or 72) towards the maximum stop (90), the starting flow control has no further effect on fuel metered to the engine. This range is overtravel and is used for convenience

to actuate the HI-IDLE system through a telescopic interconnecting linkage to the FCU on most installation.

FUEL CONTROL SYSTEM-COMPLETE OPERATION (TYPICAL)

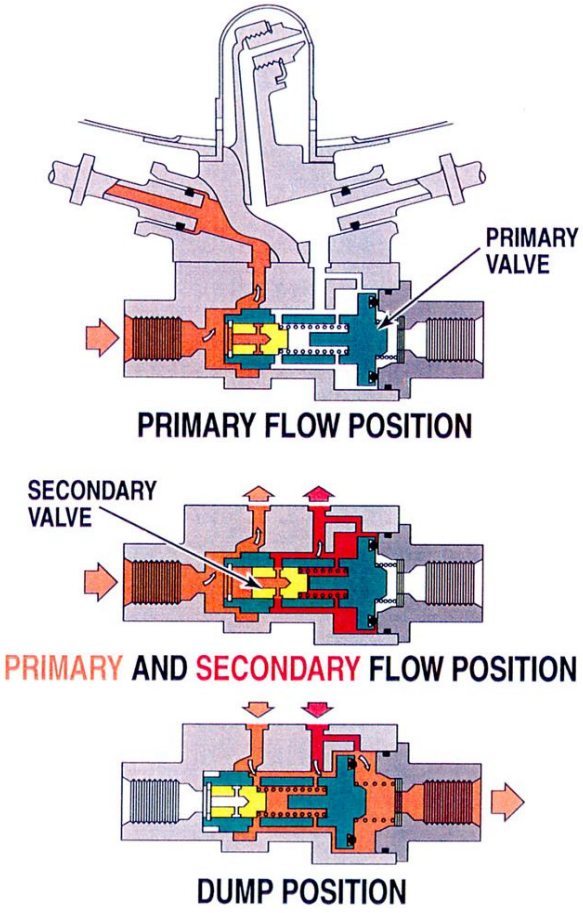
ENGINE STARTING

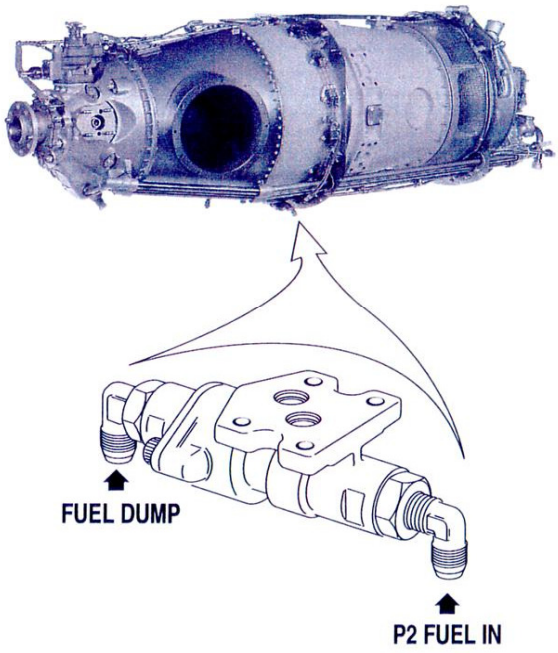
The engine starting cycle is initiated with the power control lever placed in the IDLE position and the starting control lever in CUT-OFF. The ignition and starter are switched on and, when required Ng is attained, the starting flow control lever is advanced to the RUN position. Successful ignition is normally achieved in approximately 10 seconds. After successful ignition the engine accelerates to idle. For particular engine procedures on specific aircraft installations, refer to relevant Specific Operating Instructions (SOI) or to aircraft operating Manual.

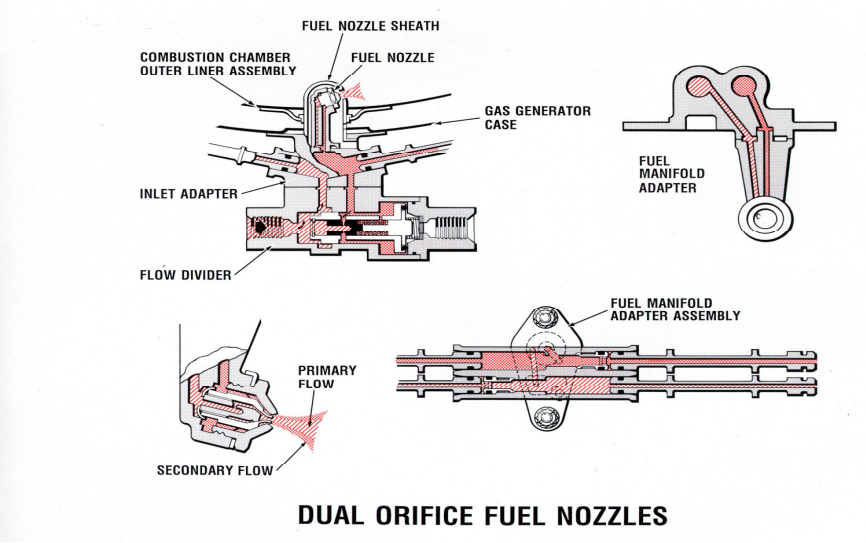
During the starting sequence, the FCU metering valve is in a low flow position. As the engine accelerates, the compressor discharge pressure (Pc)

increases, causing an increase in Px pressure. Px and Py increase simultaneously as Px = Py during engine acceleration. The increase in pressure sensed by the bellows causes the metering valve to move in an opening direction.

As Ng approaches idle, the centrifugal force of the drive body weights begins to overcome the governor spring force and to open the governor valve.







DUAL ORIFICE FUEL NOZZLES

This creates a Px – Py differential which causes the metering valve to move in a closing direction until the required-to run idle fuel flow is obtained.

Any variation in engine speed from the selected (idle) speed will be sensed by the governor weights and will result in increased or decreased weight force. This change in weight force will cause movement of the governor valve which will then be reflected by a change in fuel flow necessary to reestablish the proper speed.

ACCELERATION

As the power control lever is advanced above idle, the speed scheduling cam is repositioned, moving the cam follower lever to increase the governor spring force. The governor spring then overcomes the weights and moves the lever closing the governor valve and opening the enrichment valve. Px and Py immediately increase and cause the metering valve to move in an opening direction. Acceleration is then a function of increasing Px (Px = Py).

With the increase in fuel flow, the compressor turbine will accelerate. When Ng reaches a predetermined point (approximately 70 to 75%), weight force overcomes the enrichment valve. When the enrichment valve starts to close, Py and Px pressure increases causing an increase in the movement rate of the governor bellows and metering valve, thus providing speed enrichment to the acceleration fuel schedule. Continued movement of the enrichment lever will cause the valve to close and enrichment will then be discontinued. Meanwhile, as Ng and

hence Nf increase, the propeller to control Nf at the selected speed and to apply the increase power as additional thrust.

Acceleration is completed when the centrifugal force of the weights again overcomes the governor spring and opens the governor valve.

GOVERNING

Once the acceleration cycle has been completed, any variation in engine speed from the selected speed will be sensed by the governor weights and will result in increased or decreased weight force. This change in weight force will cause the governor valve to either open or close, which will then be reflected by the change in fuel flow necessary by the change in fuel flow necessary to re-establish the proper speed. When the FCU governs, the valve is maintained in a regulating, or “floating” position.

ALTITUDE COMPENSATION

Altitude compensation is automatic with this fuel control system since the acceleration bellows assembly is evacuated and affords an absolute pressure reference. Compressor discharge pressure is a measurement of engine speed and air density. Px is proportional to compressor discharge pressure, so it will decrease with a decrease in air density. This is sensed by the acceleration bellows which acts to reduce fuel flow.

DECELERATION

When the power control lever is retarded, the speed scheduling cam is rotated to a lower point on the cam rise. This reduces the governor spring force

and allows the governor valve to move in an opening direction. The resulting drop in Py moves the metering valve in a closing direction until it contacts the minimum flow stop. This stop assures sufficient fuel to the engine to prevent flameout. The engine will continue to decelerate until the governor weight decreases to balance the governor spring force at the new governing position.

REVERSE THRUST OPERATION

Reverse thrust can be obtained at any selected propeller speed provided that the forward speed of the aircraft on landing or during taxiing is not high enough on the way into reverse.

The FCU speed scheduling cam has a single contoured lobe operating through a cam-box which permits the scheduling of full power at each end of the power lever travel. When the power control lever is moved to the REVERSE THRUST position, the propeller pitch control and the FCU are integrated. Increased power control lever movement toward FULL REVERSE will increase compressor turbine speed (Ng) and propeller (reverse) pitch. The propeller governor is kept in an underspeeding condition in the reverse thrust range by controlling propeller speed with the Nf governing section of the propeller governor.

With correct Nf during reverse thrust operation, the governor servo will be partially open bleeding off some Py pressure. If Nf decreases, the servo

valve will move toward its closed position, increasing Py pressure and fuel flow to increase Ng, thereby increasing Nf. If Nf exceeds the desired value, the servo piston will open further to decrease Py pressure and fuel flow.

POWER TURBINE LIMITING

The Ng governor section of the propeller governor senses Py pressure through a line from the drive body adapter of the FCU. If a power turbine overspeed should occur, the air bleed orifice will be opened to bleed off Py pressure through the propeller governor. This decrease in Py will cause the metering valve in the FCU to move in a closing direction, thus reducing fuel flow and consequently gas generator speed.

ENGINE SHUTDOWN

The engine is shut down by placing the starting flow control lever in CUT – OFF position. This action moves the manually operated plunger to the CUT-OFF AND DUMP position, stopping all fuel flow to the engine and dumping the residual fuel contained in the dual manifold overboard.

FUEL MANIFOLD AND NOZZLES

The dual fuel manifold assembly (a single manifold is used on older engines) delivers a constant supply of high pressure fuel from the starting flow control to the manifold primary and secondary fuel nozzles. The dual manifold assembly consists of 14 fuel manifold adapters (seven primary, six secondary and one secondary inlet adapter) each of which incorporates a simplex fuel nozzle. The fuel manifold adapters are interconnected by fuel transfer tubes. Locking plates, secured to each manifold adapters and transfer tubes may be removed and replaced without disconnecting the remainder of the assembly.

FUEL NOZZLE ASSEMBLY

The fuel nozzle assembly consists of 14 simplex fuel nozzles fitted with swirl-type tips. These provide a finely atomized fuel spray in the annular combustion chamber liner. Each fuel nozzle assembly is secured to an individual fuel manifold adapter which extends into the combustion chamber liner. The nozzle assembly consists of a sheath, a spray nozzle assembly consists of a sheath, a spray nozzles and tip protected by a fine strainer. The sheath, which functions as a heat shield, fits over the fuel nozzle assembly. It is perforated at the flange end to permit the entry to compressor discharge air which cools the nozzle tip and helps atomize the fuel sprayed through a hole drilled in the lower side of the sheath.

The fuel nozzles are positioned on the adapters so as to produce a continuous tangential spray from one nozzle to the next in the combustion chamber liner. The combustion chamber liner is located and supported by alternate fuel nozzle sheaths. The sheaths pass through suspension collars and support brackets welded to the outer wall of the liner, thereby securely locating the front of the combustion chamber liner in the gas generator case.

CONTROLS AND INSTRUMENTATION

The following instrumentation and control are available and considered necessary for normal operation of the engine during flight, to ascertain its mechanical condition, and to ground check and adjust the power output when necessary.

POWER CONTROL LEVER

The power control lever control the gas generator speed and thus modulates engine power output from idle to takeoff. The position for idle represents the lowest permissible power. The lever is interconnected with the propeller governor and modulated engine power from full reverse thrust to takeoff.

STARTING CONTROL LEVER

The starting control lever opens and closes a manually operated plunger in the starting flow control which selects fuel cut-off and run positions. Certain installations also incorporate a hi-idle position.

PROPELLER GOVERNOR LEVER

Selection of the required propeller RPM is provided by the propeller control lever which positions the speed adjusting lever on the propeller governor. When placed in the maximum decrease RPM position, the propeller will automatically feather.

INTERTURBINE TEMPERATURE SENSING SYSTEM (T5)

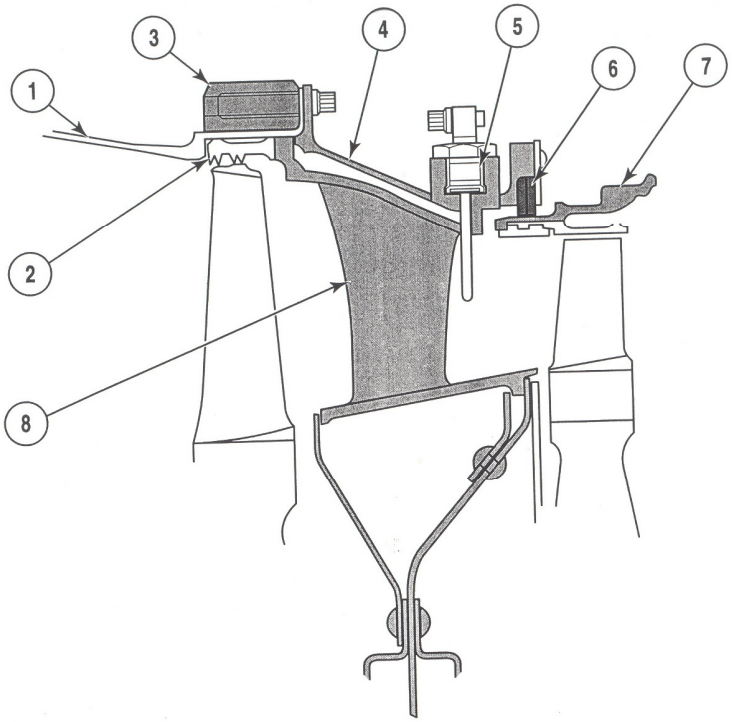
The inter-turbine temperature sensing system (T5) is designed to provide the operator with an accurate indication of engine operating temperature taken at a point between the two turbines. The system consists of twin leads, two bus bars and eight (or ten) individual chromel-alumel thermocouple probes connected in parallel. Each probe protrudes through a threaded boss on the power turbine stator housing into an area adjacent to the leading edge of the power turbine vanes,. The probe is secured to the boss by means of a floating, threaded fitting which is part of the thermocouple probe assembly. Shielded leads connect each bus bar assembly to a terminal block which provides a connecting point for external leads to a cockpit instrument. The terminal block is bolted to the gas generator case at the 2 o'clock position. The leads form the bus bars are supported by brackets welded on the stator housing and exhaust duct. The alumel and chromel terminals on the thermocouple assembly are identified AL and CR respectively. To ensure making correct connections, the chromel terminal screws are smaller than those for the alumel terminals. Thermocouples may be removed and replaced individually thereby facilitating maintenance.

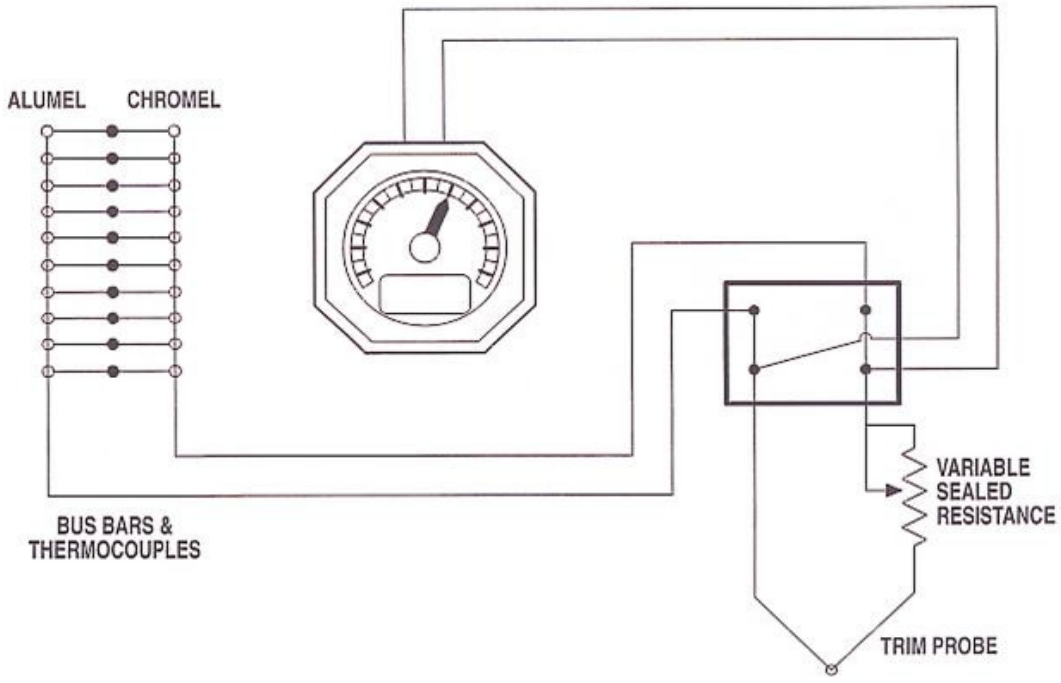
A trim harness is connected externally in parallel with the T5 harness system at terminal block to bias de ITT signal

such that the indicated ITT bears a fixed relationship with the compressor inlet turbine temperature and other parameters. This calculated temperature is the true representative of the critical component temperatures in the engine hot end. The biased indicated temperature relates to the critical component temperatures and the biasing probe compensates for sampling error in ITT indication. The trim harness consists of a T1 probe and a chromel resistor all enclosed in a stainless steel tube and is mounted externally at the 2 o'clock position in the air inlet stream just above the inlet screen. There are several classes of trim harness depending on the value of the chromel resistor. The required trim harness is selected at engine final acceptance test and may only be replaced in the field with a harness of the same class.

TURBINE INLET TEMPERATURE SYSTEM (T4) (PT6A-6,-6A, -6B AND PT6B-9 ENGINES ONLY)

The turbine inlet temperature sensing system monitors the temperature of the gases in the area immediately in front of the compressor turbine guide vanes and consists of 24 chromel/alumel thermocouple probes, a chromel and an alumel bus bar assembly and a wiring harness. The thermocouple probes are mounted in pairs on 12 brackets and connected in parallel to f two bus bars. Each bracket is secured to flange E by a centrally located bolt.





T5 SYSTEM SCHEMATIC

The probes extend through the small exit duct into the gas stream between the large and small exit ducts, through a locating ring mounted on the front face of the small exit duct. The shielded wiring harness connected to the bus bars incorporates an integral terminal block which is mounted at the 2 o'clock position on the gas generator case. The terminal block
and gasket are secured to the inner wall of the gas generator case, with the terminal posts protruding through a port in the case, to provide the connection point for the trim harness and for external wiring for cockpit instrumentation. Trim harness is provided on some overhauled engines to eliminate readout errors.

OIL PRESSURE INDICATOR

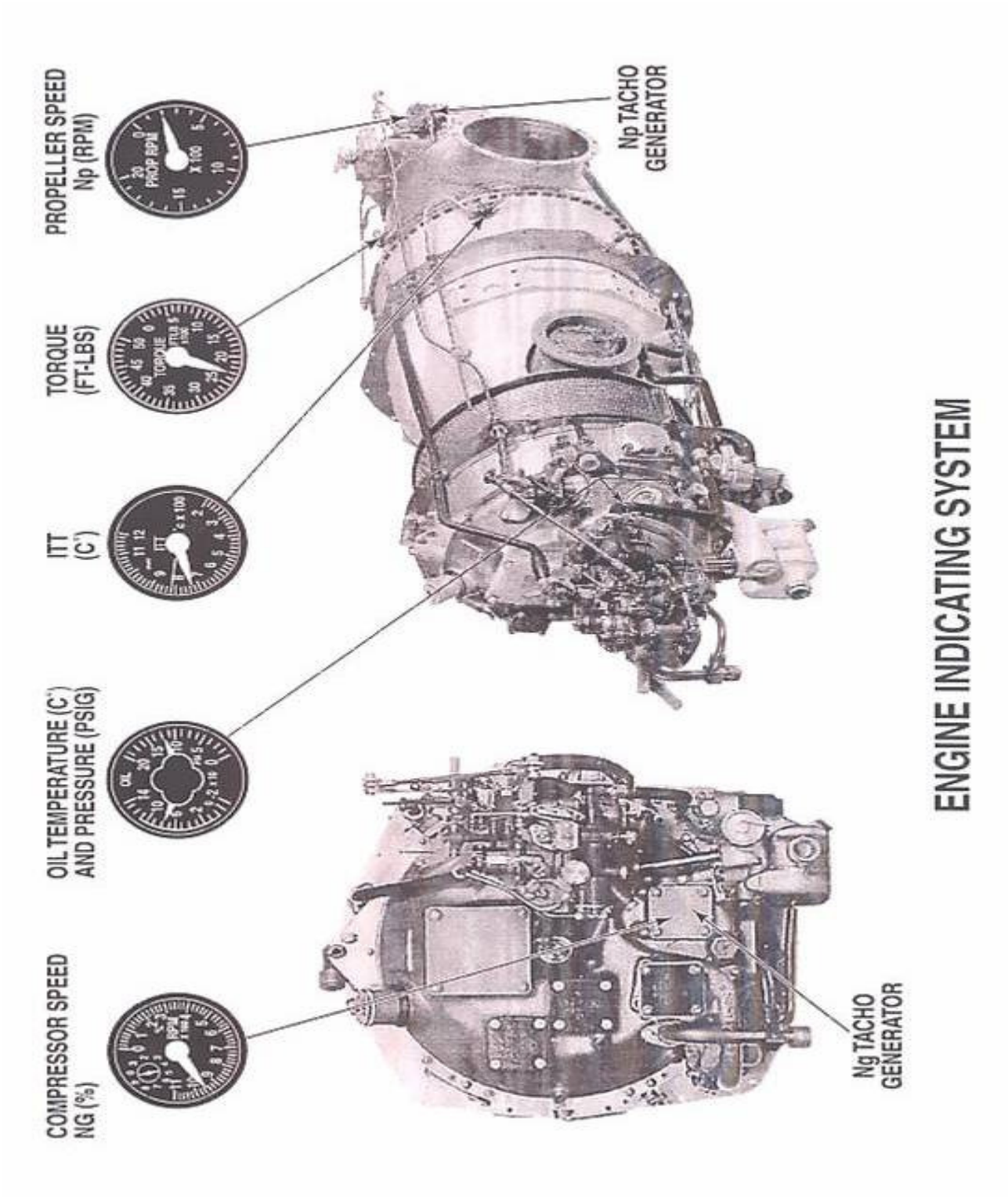
The oil pressure in the lubricating system is taken from the delivery side of the oil pump. Provision has been made to fit an oil pressure transmitter in a mounting boss located at the 3 o'clock position on the accessory gearbox housing.

OIL TEMPERATURE INDICATOR

The temperature of the lubricating oil is taken as it leaves the delivery side of the oil pressure pump. A mounting boss is provided on the accessory gearbox housing just below the oil pressure transmitter to accommodate an oil temperature bulb.

TACHOMETER-GENERATOR-GAS GENERATOR (Ng) SPEED INDICATOR

The tachometer-generator produces an electric current which is used in conjunction with a tachometer to indicate gas generator RPM. The tachometer-generator drive and mount pad are located at the 5 o'clock position on the accessory gearbox and is driven form the internal scavenge pump. Rotation is counterclockwise with a drive ratio of 0.112:1.


PROPELLER SPEED
Np (RPM)
TORQUE
(FT-LBS)
ITT
(C°)
OIL TEMPERATURE (C°)
AND PRESSURE (PSIG)
COMPRESSOR SPEED
NG (%)
Np TACHO
GENERATOR
Ng TACHO
GENERATOR
ENGINE INDICATING SYSTEM

TROUBLESHOOTING

♦ STARTING PROBLEMS

1. **NO RPM (N1) DURING START ATTEMPT.**

a. No electrical power to starter/generator.
b. Starter shaft sheared - starter only spins.
c. Starter shaft splines worn out - starter only spins.
d. N1 indication defective - is oil pressure rising? Could be defective indicator or sheared shaft
on shaft on tach drive.
e. N1 rotor system seized - remove starter and attempt to turn drive.

2. **INSUFFICIENT N1 RPM AT START ATTEMPT.**

a. Insufficient voltage to starter - check power source and leads. Are the batteries low?
b. Check N1 RPM indicating system - indicator may read low, hung up or be sticking.
c. Check N1 rotor system for rub - check turbine tip clearance. If okay, the compressor is rubbing.

3. **N1 RPM EXCESSIVELY HIGH WITH RAPID ACCELERATION**

a. Accessory gearbox input shaft is disconnected. Further start attempt by initiating fuel will cause an overtemp.

4. **DELAYED START**

a. Improper start technique - check the flight manual.
b. Fuel manifold adapters improperly positioned.
c. Fuel nozzle restriction - flow check fuel nozzles.
d. Air in the fuel system - bleed the system. Check the reason for air entering the system.
e. Check spark igniters - replace as necessary.
f. Check ignition exciter - check on air start and while motoring. Replace as necessary.
g. Check voltage to ignition exciter - low voltage may be accompanied with low cranking RPM. Can cause hot start.

5. **FAILS TO LIGHT**

a. Improper start technique- though not usually.
b. No fuel to the engine – check aircraft valve on. Check fuel boost pump pressure.
c. Excessive air in fuel system - bleed fuel system. Check the reason for air entering the system.
d. No ignition - will give wet stacks. Caused by open circuit. Let engine
e. Drain and dry motor the engine. Attempt start using air start igniters. Start accomplished-problem in aircraft electrical system. No start – change igniters and/or ignition exciter. **CAUTION: ALLOW IGNITION EXCITER OF SNAP TYPE IGNITION TO BLEED OFF**

ENERGY.

f. Fuel manifold adapters improperly installed-check proper position by proper Service Bulletin.
g. Fuel pump failure - attach direct reading line in fuel pump to FCU line. Check for proper pressure while cranking engine. Check FCU fuel filter.

N1 RPM	Fuel Pressure
15%	141 PSIG
20%	250 PSIG
25%	391 PSIG

h. Contaminated fuel system-check all filter. Clean fuel system as necessary.
i. FCU bypass valve stuck open. Check bypass valve for closing. Remove FCU cap fuel outlet and bypass fittings. Apply 5 PSI air pressure to bypass return port. If air leak is
j. Detected at fuel inlet, replace the FCU (PT6A-6, -20, -27,-28)
k. Start control defective-check primary fuel line for flow. If no flow, replace unit (Pt6a-27-28,-34).
l. Flow divider and dump valve stuck-replace unit.
m. Fuel nozzle restriction-flow check fuel nozzles.

6. **ENGINE LIGHTS BUT SLOW TO IDLE (COOL)**

a. Improper start technique - early removal of starter. Will also cause hotter than normal starts.
b. Leaking or restricted P3 signal lines - check all lines for obstruction, cracks and security. Check P3 filter for contamination.
c. Pneumatic section of prop governor of fuel topping governor affecting Py
d. signal blank Py line. PT6A-41, -25 blank also torque limiter.
e. Corrosion and/or ice in FCU bellow section –replace FCU.
f. Contaminated or defective FCU-check all fuel filters. Check FCU bypass valve.
g. Minimum fuel flow stop set too low - check minimum fuel flow. Remove Py line from prop governor of fuel topping governor and leave open. Perform normal start. Check N1 RPM per maintenance manual. **Caution: Do not attempt this procedure on PT6A-41 engines.**
Note: Usually PT6A-27 and 28 engines.
h. Hung start on PT6A-27 and –28 - check SFC dump port for fuel. If dumping, replace unit.
i. Prop slow to attain idle RPM - prop shaft transfer sleeve binding. Check covers on transfer tube bosses. Binding accessories, remove one at a time.

7. **HOT START**

a. Improper start technique - usually caused by entering fuel too early and /or early starter removal.
b. Insufficient voltage to the starter - causes lower than normal cranking RPM and loss of starter assist.
c. Deficient starter - replace unit.

d. Engine bleed air open or leaking - blank the engine bleed air port and try again.
e. Delayed igniters - check the system.
f. Minimum fuel flow stop setting too high - replace FCU.

g. Fuel nozzle restriction - flow check fuel nozzles. Spray pattern does not reach the igniters. Will cause flame out the exhaust.
h. Incorrect FCU or start rigging - re-rig as necessary.
i. Fuel manifold adapters in the wrong position - check for proper position by proper Service Bulletin.
j. Start control transfer valve stuck open - remove valve, clean and polish. Will cause secondary fuel flow during start cycle.
k. Dump valve in flow divider stuck closed - replace unit. Will not allow fuel to dump.
l. Defective N1 indicator - reads high - causes early entry of fuel.

♦ OPERATING PROBLEMS

1. PROP OVERSPEED (N2)

a. Defective prop governor - check setting. Replace unit if not adjustable.
b. Defective pneumatic section of prop or fuel topping governors - replace units.
c. Defective overspeed governor - replace unit.
d. Binding or disconnected rigging - repair or replace as necessary.
e. Defective RPM indicator - replace unit.

2. COMPRESSOR OVERSPEED (N1)

a. Sheared FCU drive coupling - replace FCU and coupling.
b. Defective FCU bypass diaphragm - replace FCU.

c. FCU bypass valve stuck closed - replace unit.

3. PROP SLOW TO FEATHER (IMMEDIATE)

a. Prop governor rigging incorrect - re-rig as necessary. Not contacting feather stop.
b. Defective prop governor-replace unit.
c. Propeller binding - check low pitch stop rods for binding. Have approved shop check feathering spring assembly for binding. Check prop blade bearings for binding-repair as necessary.

4. PROPELLER SLOW TO UNFEATHER OR FAILS TO COME OUT OF FEATHER (30 SECONDS NORMAL)

a. Prop shaft transfer housing seals leaking - remove power section at A flange and replace seals.
b. Transfer bobbin seals leaking - remove bobbins and replace seals. Do not mix bobbin covers.

c. Defective prop governor - replace unit.
d. Defective overspeed governor - replace unit.
e. Obstructed prop shaft oil passage- remove prop and inspect.
f. Propeller binding - check as above.

5. HIGH FUEL FLOW AT ALTITUDE

a. Defective indicating system-check system.

b. Defective or maladjusted compressor bleed valve - may not be closing all the way. Will cause

c. ITT and N1 RPM higher than normal.
d. P3 air leaks - check all gaskets on gas generator case for integrity and security.

6. FUEL LEAKAGE FROM FCU VENT

a. Leak originates from fuel pump drive seals - replace fuel pump. Check FCU drive bearings, if excessive wash of grease, replace unit.

7. VIBRATION

a. Prop out of balance - check prop for damage and balance. If unable to balance out vibration, check blade angle and twist.
b. Compressor out of balance - cause steady hum. Check for FOD. Check bleed valve for being stuck shut-will cause higher than normal ITT at idle.
c. Compressor out of balance - cause intermittent hoot. This condition is okay if hoot goes away by 60 % N1 RPM. Check turbine balance.
d. Power turbine out of balance - check turbine for balance and failure.

8. HIGH N1 RPM

a. Check indicating system - replace indicator as necessary.
b. Compressor dirty – perform compressor wash.

c. Compressor FOD - check first stage blades for FOD.
d. Compressor bleed valve(s) open - will give high ITT. - have bleed valve(s) bench checked.

e. Excessive P3 air leaks - check all gas generator gaskets for integrity and security.

9. UNCONTROLLED ACCELERATION

a. FCU drive sheared - replace coupling and FCU.
b. FCU bypass diaphragm ruptured - replace unit.
c. FCU bypass valve stuck closed - replaced unit.

10. STALL DURING ACCELERATION (SHOTGUN SOUND)

a. P3 inlet elbow at FCU does not have metering orifice.

b. Compressor bleed valve bleed(s) stuck shut - replace unit(s). Will cause continuos hum at idle.
c. Compressor bleed valve(s) out of calibration - have unit(s) bench checked and adjusted.
d. Defective FCU - overfueling. Replace unit.
e. Compressor FOD - check first stage compressor blades for FOD.

11. UNEQUAL ACCELERATION ON TWIN ENGINE AIRCRAFT

a. Check P3 inlet elbow at FCU for metering orifice - the fast accelerating engine may not have it.

b. Incorrect setting of acceleration dome - maximum adjustment three (3) clicks either side of datum. May have to speed one engine up and slow other down. (Clockwise to increase acceleration rate).
c. FCU air system contaminated - send unit in for cleaning or exchange.

12. FAILURE TO ACCELERATE PROPERLY

a. P3 sense line restricted or leaking - check line for obstruction.
b. Px metering orifice contaminated - remove and clean Px orifice or send in FCU for cleaning.
c. Corrosion or ice in FCU bellows section - remove FCU for cleaning. Check P3 line for water.
d. Defective FCU - replace unit.
e. Dirt in pneumatic section of FCU.
f. Contaminated P3 filter - check and change filter. Will also cause slow start.
g. Defective temperature compensator -replace unit. Try bypassing unit with slave line.

13. FAILURE TO DECELERATE

a. Disconnected or improperly rigged FCU - repair or re-rig as necessary.
b. FCU bypass valve stuck - replace unit.
c. Binding control linkage- check control linkage, repair as necessary.

14. FLAMEOUT

a. Interrupted fuel supply - aircraft fuel valve shut off inadvertently.

b. Fuel pump drive failure - preceded by slight increase in N1 RPM. Check fuel pump cranking pressure.
c. Air in fuel system - flameout at idle after a start. Bleed fuel system. Check reason for air entering fuel system. Has a part of the system been apart.?
d. Minimum fuel stop setting too low - flameout during deceleration. Remove Py line from prop governor

or fuel topping governor. Perform normal start and check N1 RPM.
e. Contaminated FCU - check all fuel filters. Clean fuel system and replace filters as necessary.

15 INCORRECT IDLE SPEED

a. Incorrect idle setting - set per maintenance manual.
b. Incorrect rigging – lengthen rod to relieve cam.
c. Minimum fuel flow stop setting too high - check minimum fuel flow. Will not decrease to idle fuel flow.
d. Air leak in P3 or Py signal lines - usually causes low idle RPM. Check lines for cracks and security.
e. FCU control rod binding - will not return to idle position. Lubricate or replace bearing ends. Lubricate and / or re-rig cam assembly.

16. LOW POWER (ALL PARAMETERS DOWN)

a. Faulty instrument(s) - have all instruments calibrated.
b. Selected wrong torque from graph - recalculate desired torque.
c. Incorrectly rigged FCU linkage - not contacting maximum stop at full throttle. Re-rig FCU.
d. Air leak in P3 or Py sense line - check P3 and Py lines for cracks and security.
e. FCU maximum stop set too low - perform part power check.
f. Fuel Nozzle restriction - partially plugged. Clean and flow check fuel nozzles. Will cause hot section distress.
g. Contaminated or defective FCU - disconnected FCU outlet and check for flow while motoring. If no flow - remove FCU for bypass valve check.
h. Dirt in pneumatic section of FCU caused incorrect signal effect. Clean or replace unit.
i. Contaminated P3 filter - restricts p3 signal. Will cause slow acceleration. Change P3 filter.
j. Defective prop governor pneumatic section or fuel topping governor - plug Py line and recheck power.
k. Prop governor pneumatic or topping governor incorrectly rigged-check arm for contact against maximum stop.
l. Torque limiter setting too low-cap Py line at torque limiter and check power. Adjust as necessary.

17. OVERTEMPERATURE (ABOVE MAXIMUM)

a. Instrument out of calibration - have all instruments calibrated.
b. Faulty T5 system - check T5 system per the maintenance calibrated.
c. Excessive accessory loading - place generator off line and recheck.
d. Replace generator and/or supercharger.
e. Torque indication low - have instrument calibrated.

18. TEMPERATURE LIMITED

a. Instruments out of calibration - have all instruments calibrated.
b. Selected wrong torque from graph - recheck.
c. Dirty compressor - perform compressor wash. Open inlet screen and check compressor.

d. Excessive accessory load - place generator off line. Check accessories for extra loading.
e. Defective compressor bleed valve(s) blowing air overboard - cause high N1 RPM.
f. Compressor FOD - check compressor first stage blades. Will have high N1 RPM.
g. Air leaks - check all gas generator case P3 gaskets and flanges for leaks.
h. Hot section distress - N1 speed down, T5 up. Perform HSI

19. INABILITY TO REACH PERFORMANCE CHECK

a. Instruments out of calibration –have all instruments calibrated.
b. Selected worn torque from graph - recheck.
c. Dirty compressor - perform compressor wash. Will cause high N1 RPM.
d. Compressor bleed valve(s) open - bench check and/or replace bleed valve. N1 RPM and ITT will be high.
e. Compressor FOD - check first stage compressor blades.
f. T5 system defective - should have been caught on first step.
g. Air leaks - check all gas generator case P3 gaskets and flanges for leaks.
h. Hot section distress - turbine tip clearance excessive, compressor turbine vanes bowed or burned changes classification.
i. Compressor turbine vane ring class is changed - first stage power turbine vane ring class may need changing.

20. LOW N1 RPM AND HIGH T5

a. Hot section distress - perform HSI

21. LOW OIL PRESSURE

a. Low oil level - check the tank oil level. Check oil consumption.
b. Defective oil pressure indication - check with direct reading gauge.
c. Pressure relief valve malfunctioning - probably stuck open. Replace unit.
d. Internal oil leak - will cause oil smoke on start or shutdown and oil smell in cabin area.
e. Failed heat shield in power section - causes excessive heating of oil. Oil cooler may not be able to handle the added temperature.
f. Oil pressure follows the throttle - can not adjust or adjustment is less than expected. Check oil pump housing for cracks or wear.
g. No oil pressure - all models. Can happen after normal filter check. Oil filter is installed backwards.

22. HIGH OIL PRESSURE

a. Defective oil pressure indication - check will direct pressure gauge.
b. Pressure relief valve malfunctioning - stuck closed. Oil pressure will follow N1 RPM.

23. HIGH OIL TEMPERATURE

a. Insufficient supply - check tank level. Replenish supply, check consumption.
b. Defective cooling system - check oil cooler thermostat. Check oil cooler for air blockage.
c. Excessive idling in feather - reduces air volume to oil cooler.
d. Failed heat shield in power section - causes excessive heating of oil. Remove and repair power section.

24. EXCESSIVE OIL CONSUMPTION

a. Extended leakage - repair oil leak.
b. Restriction in scavenge tubes - check all tubes for blockage. Unable to scavenge oil- will cause bearing area flooding.
c. Defective packing on oil filter housing - check packings.
d. Clogged scavenge screen in rear case - check main oil filter for carbon. If excessive carbon is found, pull engine to clean scavenge screen.
   Carbon originates at No.3 bearing area.
e. Defective labyrinth seals - check inlet and exhaust for oil. Will cause smoke during start and/or oil smell in cabin area. No.1 bearing - leak at inlet. No.2 bearing - smoke during start (turbine side) - puff of smoke during start and oil smell in cabin immediately after takeoff, disappears quickly.
f. Oil to fuel heater leak - oil migrating to fuel system and is burned. Change unit.
g. Oil form breather excessive - cocked or defected carbon seal.
h. Defective or missing packings on oil tank center tube - remover rear case and check packing.
i. No 1 bearing pressure and/or scavenge tube packings defective - remove rear case and check packings.
j. Defective filter check valve - will allow oil to migrate to pressure system overflowing bearing areas.
k. Seal on pressure pump backwards- will cause excessive oil in scavenge system overloading oil separator.
l. System overserviced - keep level at on quart to maximum level. Check oil immediately after shutdown.
m. If consumption still exceeds 12 lbs./ hr return engine to overhaul shop.

25. HIGH BREATHER DISCHARGE

a. Overfilled system-same as above.
b. Breather carbon seal defective - same as above.
c. Excessive back pressure in scavenge system - check scavenge tubes, oil lines and oil cooler for restriction.

26. FLUCTUATION OIL PRESSURE

a. Insufficient oil supply - replenish supply and check consumption.

b. Defective indication - loose wire in connector. Check with direct reading gauge.
c. Restricted oil filter - bypassing. Check oil filter. Debris may have clogged oil jets.
d. Pressure relief valve sticking - change or polish relief valve.

27. OIL LEAKING FROM COMPRESSOR INLET

a. Defective packings oil tank tubes - replace.
b. Defective packings on oil filter housing - replace packings.

28. OIL LEAK AT COMPRESSOR DRAIN (STATIC)

a. Defective packings on No.2 bearing scavenge bobbin.

29. FLUCTUATION (ALL PARAMETERS)

a. Faulty instruments - not usually.
b. Loose control linkage - repair or replace control linkage.
c. Power turbine pneumatic governor not on maximum stop – can cause low power. Cap Py line to confirm problem. Re-rig control.
d. Fuel pump shaft seal leaking - has washed grease from FCU bearings and started failure of these bearings.
e. FCU coupling defective - loose coupling will cause erroneous RPM signal. FCU to fuel pump may be misaligned - loosen nuts and rotate FCU and retighten nuts. Check again for fluctuation. Remove FCU and rotate coupling 180 Reinstall FCU and check again for fluctuation.
f. Defective power turbine pneumatic governor - plug Py line and check for fluctuation. If cured, replace unit.
g. P3 elbow loose - check integrity of P3 gasket and security of elbow.
h. Bleed valve moving off seat - oscillating N1 and T5 up, torque down. Bench check or exchange bleed valve(s).

30. FLUCTUATION OF PROP AND TORQUE

a. Loose linkage - check all linkage for security.
b. Defective CSU - replace unit.
c. Defective OSG - install blank to pad and run engine, replace unit.
d. Prop sticking - check low pitch top rods for sticking or rubbing. Check or change feather spring assembly.

31. HIGH T5, LOW PROP RPM AT HIGH IDLE

a. Blade angle incorrectly set - reset blade angle.

32. ENGINES ACCELERATE IN REVERSE UNEVENLY

a. FCU interconnect rods of different lengths - FCU arms not installed evenly. Dead band idle screws projection vary.

33. PROP DOES NOT INCREASE IN RPM EVENLY

a. Preload difference between engines - Recheck preload.
b. Adjustable low pitch stops set differently - recheck low pitch stop. 8-10 threads showing normal.
c. “Z” gaps set different - check blade angles setting.